US Army Corps
of Engineers®
St. Paul District

WATER CONTROL MANUAL

MISSISSIPPI RIVER NINE FOOT CHANNEL
NAVIGATION PROJECT

LOCK AND DAM NO. 10

GUTTENBURG, IOWA

APPENDIX 10 OF THE MASTER WATER CONTROL MANUAL

UPDATED JULY 2004

WATER CONTROL MANUAL

LOCK AND DAM No. 10
GUTTENBERG, IOWA

UPPER MISSISSIPPI RIVER BASIN
MISSISSIPPI RIVER – NINE FOOT CHANNEL
NAVIGATION PROJECT

APPENDIX No. 10
of the
MASTER WATER CONTROL MANUAL

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

JULY 2004

Updated from
Reservoir Regulation Manual, December 1972
Operation of Navigation Pools, February 1943

LOCK AND DAM No. 10

GUTTENBERG, IOWA

Aerial View Looking South – 1991

4 Roller Gates and 8 Tainter Gates
Project Pool 611.0 feet (1912 Adjustment)

LOCK AND DAM No. 10

GUTTENBERG, IOWA

Lock and Dam No. 10 Central Control House

NOTICE TO USERS OF THIS MANUAL

This Water Control Manual complies with the latest US Army Corps of Engineers guidelines regarding management of water control systems and preparation of water control manuals. The St. Paul District prepared the *Preliminary Report on Operation of Navigation Pools* on 16 February 1943. This document provided the operational information for Lock and Dams 1 through 10. A Master Regulation Manual replaced it in September 1969. Appendices for each lock and dam were added during the years 1969 through 1972, with Appendix No. 10 being completed in December 1972. This manual is an update of Appendix No. 10. The manual is published in loose-leaf form to facilitate modifications. In the future, only those sections, or parts thereof, requiring changes will be revised and replaced.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise (e.g. gate failure, excessive rainfall), the Lockmaster, Area Lockmaster, and Water Control should be notified as to the extent of the event. During normal water control duty hours (i.e. 0630 to 1730 hrs weekdays and 0630 to 1030 hrs weekends and holidays), contact with water control can be made at 651-290-5624 or 651-290-5474. On weekends and holidays, the Mississippi River Duty Regulator Pager number can be used. If communication with Water Control cannot be established, the following list can be used as a guide for establishing contact.

Water Control Regulation Assistance		
Scott R. Bratten	Primary Mississippi River Regulator scott.r.bratten@usace.army.mil	Duty: 651-290-5624 Non-Duty: 651-436-6135
Duty Regulator	Mississippi River Duty Regulator; Pager and Fax	Pager: 612-660-8053 Fax: 651-290-5841
Dennis D. Holme	Physical Scientist dennis.d.holme@usace.army.mil	Duty: 651-290-5614 Non-Duty: 651-483-4003
Theodore D. Petersen	Water Control Gage Crew theodore.d.pedersen@usace.army.mil	Duty: 651-290-5253 Non-Duty: 715-639-2625
Farley R. Haase	Water Control Gage Crew farley.r.haase@usace.army.mil	Duty: 651-290-5633 Non-Duty: 715-235-1928
Ferris W. Chamberlin	Hydraulic Engineer ferris.w.chamberlin@usace.army.mil	Duty: 651-290-5619 Non-Duty: 651-653-7981
Robert G. Engelstad	Chief, Water Control Section robert.g.engelstad@usace.army.mil	Duty: 651-290-5610 Non-Duty: 651-459-6343
Michael R. Knoff	Chief, Hydraulics & Hydrology Br michael.r.knoff@usace.army.mil	Duty: 651-290-5600 Non-Duty: 651-458-0502
John J. Bailen	Chief, Engineering Division john.j.bailen@usace.army.mil	Duty: 651-290-5303

Lock and Dam No. 10
Guttenberg, Iowa

U.S. Army Corps of Engineers
St. Paul District – July 2004

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Drainage Area: 79,370 square miles **Datum:** MSL - 1912 adjustment

Fixed Height Dam:

Type:	Earth Dike with Ogee Spillway	
Length of Earth Dam	4,547 feet	
Crest of Earth Dam	Elevation 624.0 feet	
Top Width of Earth Dam	20 feet	
Max Height of Earth Dam	28 feet	
Ogee Spillway		
Length:	1,200 feet	
Crest:	Elevation 611.0 feet	

Movable Dam:

Roller Gates	4 Gates	80 feet by 20 feet
Tainter Gates	8 Gates	40 feet by 20 feet
Roller Gate Sill	Elevation 591.0 feet	
Tainter Gate Sill	Elevation 591.0 feet	

Lock:

Main Lock Chamber	110 feet by 600 feet
Top of Lock Walls	Elevation 624.0 feet
Top of Upper Gate Sill (Main)	Elevation 596.0 feet
Top of Upper Gate Sill (Auxiliary)	Elevation 591.0 feet
Top of Lower Gate Sill	Elevation 591.0 feet
Lock Floor	Elevation 589.0 feet
Height of Upper Miter Gates (Main)	25.0 feet
Height of Upper Miter Gates (Aux.)	30.0 feet
Height of Lower Miter Gates	30.0 feet

Pool:

Normal (Project) Upper Pool	Elevation 611.0 feet	
Normal (Project) Lower Pool	Elevation 603.0 feet	
Total Pool Area (at Project Pool)	17,070 acres	
Primary Control Point	Lock & Dam 10	Elevation 611.0 ft
Secondary Control Point	Clayton, Iowa	Elevation 611.8 ft
Tertiary Control Point	Lock & Dam 10	Elevation 610.0 ft

Notes:
1. None of the four roller gates are submergible.
2. Tainter gates 1 and 12 are submergible to 3.0 ft below Normal Pool.

I – INTRODUCTION

1-01. Authorization for Preparation of this Manual. Pursuant to the instructions from the Chief of Engineers dated 15 May 1942 and 29 August 1942, subject "*Operation of Flood Control and Multiple-Purpose Reservoirs*", the methods and the technique used in operating the navigation pools on the Mississippi River in the St. Paul District was documented in February 1943. Authority to prepare regulation manuals for the locks and dams was granted by Engineering Regulation (ER) 1110-2-240, *Reservoir Regulation*, 1958. While ER 1110-2-240 has been updated and amended many times since the date of issuance, the document continues to give the Corps of Engineers authority to prepare what became known as "Water Control Manuals" by ER 1110-2-240, *Water Control Management*, 1982. This manual supercedes Lock and Dam No. 10 Regulation Manual dated December 1972 and was prepared in compliance with the guidelines presented in:

a. Engineering Regulation, ER 1110-2-240, *Water Control Management*, 8 October 1982, amended 30 April 1987 and 1 March 1994.
b. Engineering Manual, EM 1110-2-3600, *Management of Water Control Systems*, 30 November 1987.
c. Division Regulation, DIVR 1110-2-240, *Water Control Management, Preparation of Water Control Plans and Manuals*, 1 January 1992.
d. Engineering Regulation, ER 1110-2-8156, *Preparation of Water Control Manuals*, 31 August 1995.

1-02. Purpose and Scope. The purpose of this manual is to provide guidance and instruction for project personnel and to serve as a reference source for others who may be involved with the regulation of this project. The manual is for daily use in Water Control Section activities for most foreseeable conditions and occurrences. The manual covers all water control management activities as they relate to the hydraulic and hydrologic aspects of the project.

1-03. Related Manuals and Reports. The Upper Mississippi River Lock and Dam system was authorized when Congress approved the nine-foot channel on 3 July

1930. A general scheme of operation was developed on 28 March 1935. The following is a list of related Manuals and Reports in chronological order.

a. *Survey of Mississippi River Between Missouri River and Minneapolis,* Letter from The Secretary of War, 72 Congress, 1st Session, House Document No. 137, Part 1 – Report, 9 December 1931.
b. *Report on General Scheme of Operation for the Dams of the 9-Foot Channel Project,* by J. A. Grant, Senior Engineer, War Department, Office of the Chief of Engineers, 28 March 1935.
c. *Preliminary Report on Operation of Navigation Pools,* War Department, US Engineer Office, St. Paul District, St. Paul, Minnesota, 16 February 1943.
d. *Master Regulation Manual for Mississippi River Nine-Foot Channel Navigation Projects*, US Army Corps of Engineers, St. Paul District, September 1969.
e. *Mississippi River Nine-Foot Channel Navigation Project, Reservoir Regulation Manual, Appendix 10, Lock and Dam No. 10, Guttenberg, Iowa,* US Army Corps of Engineers, St. Paul District, December 1972.
f. *Final Environmental Impact Statement for Operation and Maintenance of the 9-Foot Navigation Channel, Upper Mississippi River, Head of Navigation to Guttenberg, Iowa*, US Army Corps of Engineers, St. Paul District, 1974.
g. *Creativity, Conflict & Controversy: A History of the St. Paul District, US Army Corps of Engineers,* by Raymond H Merritt, 1979.
h. *Final Environmental Impact Statement:* Great River Environmental Action Team I Study of the Upper Mississippi River, Guttenberg, Iowa, to the Head of Navigation at Minneapolis, Minnesota; Great River Environmental Action Team (GREAT), Volume 9, 1980.
i. *Upper Mississippi River, Land Use Allocation Plan*, Master Plan for Public Use Development and Resource Management, Part I and Part II, US Army Corps of Engineers, St. Paul District, September 1983.
j. *Scour Protection for Locks and Dams 2-10, Upper Mississippi River,* Technical Report HL-87-4, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, April 1987.
k. *Environmental Assesment:* Major rehabilitation, Locks and Dams 2 through 10, Upper Mississippi River, US Army Corps of Engineers, St. Paul District, 1987.
l. *Commerce and Conservation on the Upper Mississippi River,* by John O. Anfinson, District Historian, US Army Corps of Engineers, St. Paul District, St. Paul Minnesota, 1990.
m. *Gateways to Commerce*, The US Army Corps of Engineers' 9-Foot Channel Project on the Upper Mississippi River, National Park Service, Rocky Mountain Region, 1992.
n. *Authorized and Operating Purposes of Corps of Engineers Reservoirs,* US Army Corps of Engineers, Washington D. C., July 1992.
o. *Zebra Mussel Research*, Technical Notes, US Army Corps of Engineers, Waterways Experiment Station, Technical Note ZMR-1-30, October 1995.

p. *Emergency Plan for Lock and Dam 10, Guttenberg, Iowa*, US Army Corps of Engineers, St. Paul District, June 1995.
q. *Final Environmental Impact Statement*: Long term channel maintenance plan for the Federal harbor and a permit application to construct and expand barge terminal facilities in the East Channel of the Upper Mississippi River at Prairie du Chien, Wisconsin; US Army Corps of Engineers, St. Paul District and Wisconsin Department of Natural Resources, 1996.
r. *Channel Maintenance Management Plan,* Upper Mississippi River Navigation System, US Army Corps of Engineers, St. Paul District, 1996.
s. *Effects of Increased Commercial Navigation Traffic on Freshwater Mussels in the Upper Mississippi River: Final Synthesis Report,* US Army Corps of Engineers, Waterways Experiment Station, TR EL-96-6, May 1996.
t. *Channel Maintenance Management Plan, Final Environmental Impact Statement (FEIS),* Lead Agency US Army Corps of Engineers, St. Paul District, Volumes I and II, 6 June 1997.
u. *Record of Decision (ROD) for Final Environmental Impact Statement, Channel Maintenance Management Plan,* Major General Robert B. Flowers, Commander and Division Engineer, Mississippi Valley Division, US Army Corps of Engineers, June 1997.
v. *Zebra Mussel Response Plan*, Environmental Section, St. Paul District, US Army Corps of Engineers, November 1997.
w. *Locks and Dams Sounding Reports, Volume 2,* US Army Corps of Engineers, St. Paul District, 1999.
x. *Discharge Ratings for Control Gates for Lock and Dam 9 (Lynxville, WI) and Lock and Dam 10 (Guttenberg, IA),* US Army Corps of Engineers, St. Paul District (prepared by Barr Engineering Company), January 1999.
y. *Biological Opinion for the Operation and Maintenance of the 9-Foot Navigation Channel on the Upper Mississippi River System,* US Fish and Wildlife Service, 15 May 2000.
z. *2001 Annual Report – Water Quality Management Program,* US Army Corps of Engineers, St. Paul District, January 2002.
aa. *Lock and Dam 10 Sounding Analysis,* US Army Corps of Engineers, St. Paul District, 2002.
bb. Engineering Regulation, ER 200-1-5, *Policy for Implementation and Integrated Application of the US Army Corps of Engineers (USACE) Environmental Operating Principles (EOP) and Doctrine*, 30 October 2003.

1-04. Project Owner. The United States Government is the owner of Lock and Dam No. 10.

1-05. Operating Agency. Lock and Dam No. 10 is operated by the US Army Corps of Engineers, St. Paul District. Operation and maintenance is the responsibility of Operations Division.

1-06. Regulating Agency. Regulation of Lock and Dam No. 10 is under the supervision of the Water Control and Hydrology Section in the Hydraulics and Hydrology Branch, Engineering and Construction Division.

The project is attended 24 hours a day, every day of the year. The Chief, Operations Division and the Chief, Engineering and Construction Division are located in the St. Paul District Office, whereas the Lock and Dam Project Office is located in Fountain City, Wisconsin. The Area Lockmaster is stationed at Lock and Dam No. 9.

II – DESCRIPTION OF PROJECT

2-01. Location. Lock and Dam No. 10 is located on the Mississippi River, 615.1 river miles above the mouth of the Ohio River, 32.8 river miles below Lock and Dam No. 9, and 32.1 river miles above Lock and Dam No. 11. The lock is on the right bank of the river adjacent to Guttenberg, Iowa, at approximate latitude 42° 47' 6" N and longitude 91° 5' 42" W. Clayton and Allamakee Counties border the project on the Iowa side and Grant and Crawford Counties on the Wisconsin side. The project location is shown on **Plate 2-1**.

2-02. Purpose. Lock and Dam No. 10 is a unit of the Inland Waterway Navigation System of the Upper Mississippi River Basin. The system includes 29 locks and dams, which provide a "stairway of water" from Minneapolis, Minnesota to St. Louis, Missouri. The primary purpose of the dams is to maintain a depth of nine feet for navigation. The authorized purposes for Lock and Dam No. 10 are navigation under the River and Harbors Act of 1930 (PL 71-250) and recreation under the Flood Control Act of 1944 (PL 78-534). Access and facilities are provided for recreation but water is not controlled for that purpose.

2-03. Physical Components. As presented to Congress, Lock and Dam No. 10 was to be located on the left bank of the Mississippi River at Cassville, Wisconsin. This location is 1.1 miles downstream of the Turkey River. It was therefore located in Rock Island District (MVR). While the location was later moved upstream seven miles, putting it in St. Paul District (MVP), it was still designed by MVR. Hence the design is somewhat different from the locks and dams upstream. For example, the tainter gates are 40 feet wide and 20 feet high whereas the standard in MVP is 35 feet wide and 15 feet high.

Lock and Dam No. 10 consists of a main and uncompleted auxiliary lock, a movable dam section, a spillway section and an earthen dike. The locks and moveable dam are supported on timber piling driven into sand and gravel. All but the earthen dike have sheet pile cutoff walls.

Figure 2-1. Lock and Dam No. 10 (Looking Downstream)

a. Lock. Lock and Dam No. 10 has a main and an uncompleted auxiliary lock (**Plate 2-1**). The upper and lower miter gates of the main lock have a height of 25.0 feet and 30.0 feet respectively. The upper sill is at elevation 596.0 feet while the lower sill is at elevation 591.0 feet (1912 adjustment). A walkway is located atop the miter gates. It extends three feet above the top of miter gates (elevation 621.0 feet) to meet the top of lock walls (elevation 624.0 feet). While the main lock is fully functional, the auxiliary lock consists of only an upper gate bay. The miter gates on the auxiliary lock are 30 feet high with a sill elevation of 591.0 feet. The gates of the auxiliary lock have no machinery and therefore are inoperable. In theory, a gate from the auxiliary lock could be used to replace a damaged lower gate in the main lock. This would require bulk heading of both locks. The operation would require assistance from Rock Island District.

The main lock is 110 feet wide with a clear length of 600 feet. Filling and emptying of the lock chamber is controlled by tainter valves; two at the upstream (upper) end of the lock and two at the downstream (lower) end. During the filling or emptying process, the miter gates are closed thus sealing the lock chamber. For a filling operation, the upper tainter valves are opened allowing flow to enter the culverts (**Plate 2-2**, Section C-C). Flow then enters the lock chamber through ports along the lock wall (Section X-X) and the water level in the lock chamber rises until it equals the pool elevation. The upper tainter valves are then closed and the lower tainter valves are opened thus emptying the lock chamber. Under normal conditions, filling and emptying times are about eight minutes.

Periodically, the lock chamber is flushed of sediment and debris. This is accomplished at the end of an emptying cycle. The upper miter gates and lower tainter valves are in the closed position, the lower miter gates are opened in the recessed position, and the upper tainter valves are operated to provide the flushing action.

Guide walls are located upstream and downstream of the lock to provide a landing for down bound and up bound tows (**Plate 2-1**). The upper guide wall extends 517 feet upstream and the lower guide wall extends 500 feet downstream.

b. Moveable Dam. The moveable dam section extends from the auxiliary lock to the earthen dam (**Plate 2-1**). The moveable dam consists of four roller gates; 80-feet wide by 20-feet wide, and 8 tainter gates; 40-feet wide by 20-feet high (**Figure 2-1**). Gates are numbered starting at the auxiliary lock.

Numbering of Gates

tainter no.1	tainter no. 2	roller no. 3	roller no.4	roller no. 5	roller no. 6	tainter no. 7	tainter no. 8	tainter no. 9	tainter no. 10	tainter no. 11	tainter no. 12

Note that the first two tainter gates (gates 1 and 2) are located between the auxiliary lock and the roller gates. Tainter gates number 1 and number 12 can be submerged up to three feet below normal pool elevation. Both the roller gates and the tainter gates have a sill elevation of 591.0 feet (1912 adjustment). The top of end sill elevation for the roller and tainter gates is 590.0 feet and 592.0 feet respectively. The end sills have a series of 4-foot wide notches that are spaced at 15- and 17-feet on center. The depths of the notches are 3 feet for the roller gates and 2 feet for the tainter gates. For computation of flow velocities, the average end sill elevations for the roller and tainter gates 589.2 feet and 591.3 feet respectively. None of the roller gates can be submerged below normal pool (elevation 611.0 feet).

Each roller gate is equipped with an individual electrically operated hoist enclosed in an operating house located on the pier. The roller gates are driven from one end only. The travel rate of the gate is approximately 0.75 feet per minute. A position indicator (**Figure 2-2**), marked in increments of 0.1 feet, is attached to the hoist mechanism.

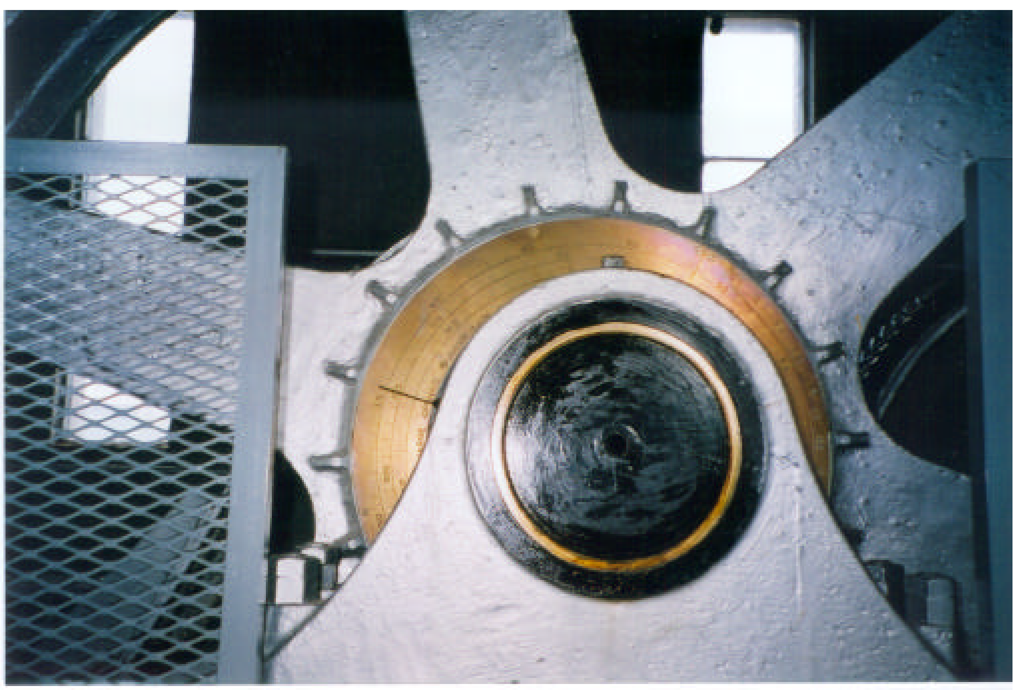


Figure 2-2. Roller Gate Position Indicator

There are six roller gate bulkheads stored on site. Each one measures 4 feet by 82 feet-7 5/8 inches. The sill elevation is 591.0 feet; therefore, with six bulkheads in place, the top of the bulkheads would be at elevation 615.0 feet.

Each tainter gate is individually operated by machinery consisting of an electrically operated central driving unit and two chain hoisting units. The electric controls consist of push buttons located on the deck rail. A position indicator (**Figure 2-3**) is mounted on top of the strut arm near the trunion. The indicator is marked in 0.5-foot increments. The tainter gates move at a rate similar to the roller gates. There are fourteen bulkheads stored on site measuring 1 foot–8 5/8 inches by 42 feet-6 inches. The sill is at elevation 591.0 feet. With thirteen bulkheads in place, the top of the bulkheads would be at elevation 613.34 feet (i.e. 613 feet-4 1/8 inches).

Figure 2-3. Tainter Gate Position Indicator

A service bridge, at elevation 643.1 feet, spans the entire length of the moveable dam and storage yard and provides for the operation of the crane. The original 40-foot boom crane, with 20-ton capacity, was replaced in 2001. The new crane has a boom length of 60 feet and a capacity of 20 tons.

c. Earthen Dam. An earthen dam, 4,547 feet in length, extends from the end of the moveable dam section to the high ground on the Wisconsin side of the river (**Plate 2-1**). The dam has a crest elevation of 624.0 feet (1912 adjustment). It has a top width of 20 feet, with a roadway, and a maximum height of 28 feet (**Plate 2-2**). The pool side slope is 1V:3H, while the tailwater slope is 1V:4H.

d. Spillway. Within the earthen dam is a 1,200-foot fixed crest concrete "ogee" spillway (**Plate 2-1**). The spillway, which is located at Cassville Slough, has a crest elevation of 611.0 feet (i.e., project pool elevation). The spillway includes a concrete apron at elevation 605.0 feet and baffle blocks (**Plate 2-2**). In 1960, two slots, five feet wide and three feet deep, were cut into the spillway to provide aeration to backwater area downstream of the dam. At project pool elevation of 611.0 feet, a continuous flow of 135 cfs is maintained. As computed by: $Q=CLH^{3/2} = (2.6)(10)(3)^{3/2} = 135$cfs.

e. Channel Protection. Immediately upstream and downstream of the moveable dam, the channel is protected by concrete followed by stone protection. Sections B-B and C-C of **Plate 2-2** show the original derrick stone protection. Over the years, scour upstream and downstream of the dam caused some unraveling of the derrick stone. In 1983, riprap protection was extended upstream and downstream in the form of capstone and rockfill. **Plate 2-3** shows two transects of the added protection. The following gives a description of the riprap protection near the roller gates, tainter gates, lock, auxiliary lock, spillway, storage yard, and the earthen dam.

(1) Roller Gates. Downstream protection originally consisted of derrick stone 6.5-feet thick with a top of rock elevation of 587.0 feet (1912 adjustment). The derrick stone extended 50 feet downstream of the end sill. Upstream protection consisted of a 20-foot wide, 3-foot thick section of derrick stone with a top elevation of 590.0 feet.

In 1983, capstone and rockfill were placed downstream of the dam to supplement the original scour protection. Downstream of the roller gates, a 42-inch thick capstone section was placed adjacent to the derrick stone protection, to a point 55 feet downstream of the derrick stone. Beneath the capstone, a minimum 30-inch thick rockfill section was placed to a maximum distance of 125 feet downstream of the roller gate end sill. Upstream of the roller gates, a 42-inch thick capstone section, with a top elevation of 590.0 feet, was placed to a point 25 feet upstream of the roller gate piers. A minimum 30-inch thick rockfill section was placed beneath the capstone and extended to a maximum distance of 65 feet upstream of the roller gate piers.

(2) Tainter Gates. Downstream protection originally consisted of derrick stone 5.5-feet thick with a top of rock elevation of 590.0 feet (1912 adjustment). It extended 25 feet downstream of the end sill. Upstream protection consisted of a 20-foot wide, 3-foot thick section of derrick stone with a top elevation of 590.0 feet.

In 1983, capstone and rockfill were placed downstream of the dam to supplement the original scour protection. Downstream of the tainter gates, a 42-inch thick capstone section was placed adjacent to the derrick stone protection, to a point 55 feet downstream of the derrick stone. Beneath the capstone, a minimum 30-inch thick rockfill section was placed to a maximum distance of 199 feet downstream of the tainter gate end sill.

Upstream of the two tainter gates west of the roller gates, a 42-inch thick capstone section – with a top elevation of 590.0 feet – was placed to a point 25 feet upstream of the tainter gate piers. A minimum 30-inch thick rockfill section was placed beneath the capstone and extended to a maximum distance of 80 feet upstream of the riverward lock wall. Upstream of the remaining six tainter gates, a 42-inch thick, 45-foot wide capstone section was placed as needed to provide additional scour protection for the existing rock. A minimum 30-inch thick rockfill section was placed beneath the capstone and extended to a point 65 feet upstream of the end of the tainter gate piers.

(3) Lock and Guide Walls. The original scour protection placed at the lock and along the downstream guide wall was a combination of rock filled cribs and derrick stone. A 20-foot wide by 436-foot long section of rock filled cribs was placed on the riverward side of the intermediate lock wall. A 12-foot wide section of derrick stone protection was provided from the downstream end of the concrete paving on the auxiliary lock, downstream along the riverward side of the intermediate lock wall (riverward of the timber cribs), and along the concrete apron on the downstream side of the landward lock. The derrick stone section was 3 feet thick with a top of rock elevation of 587.0 feet downstream of the auxiliary lock and adjacent to the rock filled cribs, and 588.0 feet at the downstream apron. A 2-foot thick, 20-foot wide riprap section was placed along the entire length of the lower guide wall to a top of rock elevation of 590.5 feet. Upstream scour protection consisted of a 2-foot thick, 20-foot wide horizontal riprap section placed along the entire upper guide wall. The horizontal rock section sloped downward at 1V:2H to meet the existing channel bed. No rock protection was originally placed upstream of the locks themselves.

Additional scour protection was placed along the upstream and downstream apron of the main lock chamber and the upper and lower guide walls in the early 1980s. The area downstream of the apron had experienced scour and undermining of the apron had occurred. The undermined area was filled with sand topped off with grout. A 20-foot wide horizontal section of ½- to 3-ton stone underlain by rockfill was placed downstream of the apron, to a top of rock elevation equal to the top of the apron. The horizontal rock section sloped downward at 1V:3H to meet the existing downstream channel bed.

Scour had progressed to the point of undermining both the upper and lower guide walls. Along the entire length of the upper and lower guide wall, a 20-foot wide rockfill section was placed on the existing ground up to an elevation of 595.0 feet and 590.5 feet, respectively. Twenty feet from the wall, the rock surface sloped down at 1V:2H to meet the existing channel bed. In 1983, a minimum 30-inch thick rockfill section was placed to a point approximately 150 feet downstream and 80 feet upstream of the riverward lock wall at the auxiliary lock.

In 1988, more repair work was required. Along the first 320 feet of the lower guide wall, a 20-foot wide horizontal riprap section, a minimum of 30-inches thick, was placed with a top of rock elevation of 590.5 feet. Twenty feet from the wall, the rock surface sloped down at 1V:2H to meet the existing channel bed. Upstream of the upstream apron and along the first 70 feet of the upper guide wall, a 30-inch minimum thick riprap section was placed to a top of rock elevation of 591.5 feet. Along the remaining guide wall length, a 20-foot wide horizontal riprap section was placed to a top of rock elevation of 595.0 feet. Twenty feet from the wall, the rock surface sloped down at 1V:2H to meet the existing channel bed.

(4) Spillway. Original scour protection downstream of the spillway consisted of riprap underlain by gravel placed on a 1V:2.5H slope for a distance of about 25 feet downstream of the end sill.

(5) Storage Yard. Original scour protection downstream of the storage yard consisted of riprap placed on a 1V:3H slope for a maximum distance of about 120 feet. Upstream protection consisted of riprap placed on a 1V:3H slope for a maximum distance of about 80 feet.

In 1983, the original scour protection was supplemented by the placement of rockfill. Downstream of the storage yard, a minimum 30-inch thick rockfill section was placed to a distance of 225 feet downstream of the storage yard. No additional rockfill was placed upstream of the storage yard.

(6) Earthen Dam. The side slopes are protected by 18-inch riprap underlain by 6-inches of gravel. Protection on the pool side extends to the dam crest; whereas protection on the tailwater slope extends to three feet above the lower project pool elevation (i.e. 603.0 + 3.0 = 606.0 ft – 1912 adjustment).

2-04. Related Control Facilities. There are no related control facilities in Pool No. 10; however, a number of habitat restoration projects have been constructed in Pool No. 10, including the Guttenberg Waterfowl Ponds, Bussey Lake, Ambrough Slough, and Mississippi River Bank Stabilization habitat projects.

a. Guttenberg Waterfowl Ponds. The Guttenberg Waterfowl Ponds Habitat Project is located below the Lock and Dam No. 10 dike at Guttenberg, Iowa (**Figure 2-5**). Water is supplied to the ponds via a 275-foot long by 2-foot diameter steel pipe that was installed in the existing Dam No. 10 spillway in 1990. A knife gate controls flow in the pipe. At project pool elevation (611.0 feet), with the gate wide open, a continuous flow of approximately 7 cfs is provided. This equates to 80 acre-ft of water to the ponds over a six-day period. The pipe helps maintain water levels in three existing ponds, encompassing a total of 35 acres. Ditching within the ponds provides drainage to an outlet structure for discharge back into the channel below the spillway. The project is intended to increase vegetation coverage and plant species diversity, and to provide good habitat for wading birds, rails, snipes, and passerines. The waterfowl ponds were constructed between 1989 and 1991, and modified between 1992 and 1997 as part of the Bussey Lake habitat project. Operation and maintenance of the project has been transferred to the US Fish and Wildlife Service.

Figure 2-4. Guttenberg Waterfowl Ponds

b. Bussey Lake. Bussey Lake is a 213-acre backwater lake on the Iowa side of the Mississippi River, about 2 miles above Lock and Dam No. 10 (**Figure 2-4**). The Bussey Lake Habitat Project, which was completed in June 1996, included two stages: (1) dredging 12,000 linear feet of channels in the lake to restore fish habitat; and (2) installation of a gate on an existing culvert to control flow and sediment from Buck Creek, which enters the north end of Bussey Lake. Half of the dredged material was placed at the Guttenberg Waterfowl Ponds project to create an additional moist soil unit and to improve the operation of the existing ponds. The remaining material was placed at the Willow Island placement site just downstream of Bussey Lake in Pool No. 10.

Figure 2-5. Bussey Lake

c. **Ambrough Slough.** Ambrough Slough is a side channel on the Wisconsin side of the Mississippi River that is located about 5 miles upstream of Prairie du Chien, Wisconsin (**Figure 2-6**). The slough enters a 2,500-acre backwater complex of lakes and smaller sloughs. The Ambrough Slough Habitat Project involves dredging in several backwater lakes to restore important fish habitat that has been lost to siltation and aquatic plant decomposition. In addition, a culvert will be installed under Ambro Road to introduce fresh water into Gremore Lake, improving dissolved oxygen levels. In all, the project will directly improve 585 acres of fish habitat in backwater lakes, as well as providing secondary benefits to additional adjacent backwaters. Project construction is ongoing.

Figure 2-6. Ambrough Slough

d. Bank Stabilization. Riverbank erosion affects backwater areas and habitat due to loss of landmass and associated increase of flow and/or sedimentation. This results in the loss and shallowing of aquatic habitat in adjacent backwaters and adversely affects circulation patterns and water quality in those areas. The Mississippi River Bank Stabilization Habitat Project directly reduced erosion and has created about 4 acres of rock habitat, beneficial to species of fish such as smallmouth bass, at 12 locations representing 12,000 feet of riverbank in pools 5 through 10. Five of these sites are located in Pool No. 10.

2-05. Real Estate Acquisition. In Pool No. 10, 9,064 acres are held in fee by the US Government. Of this total, 3,721 acres are under the jurisdiction of the Corps of Engineers, and the balance of 5,343 acres is under the jurisdiction of the US Fish and Wildlife Service (USFWS). Of the Corps of Engineers land, all but 2 acres at the dam site are managed by the USFWS as part of the Upper Mississippi River National Wildlife and Fish Refuge.

2-06. Public Facilities. In addition to the facilities at Lock and Dam No. 10, there are numerous other facilities located throughout the pool. **Tables 2-1 and 2-2** show a list of the recreational facilities located in Pool No. 10 on the Mississippi River, and below Lock and Dam 10 but in the St. Paul District.

Table 2-1
Recreation Facilities on the Mississippi River Below Pool 10 in St. Paul District

River Mile	Name	Manager	Fee	Slips	Parking	Camp Sites	Toilets	Picnic Tables
615.0L	Spillway Fishery	FWS			4	No	No	No
614.7R	615 Landing	Concession	Yes	10	10	No	Yes	No
614.5R	Guttenberg Landing	Guttenberg & IA DNR			60	No	Yes	No

Table 2-2 Recreation Facilities on the Mississippi River in Pool 10								
River Mile	Name	Manager	Fee	Slips	Parking	Camp Sites	Toilets	Picnic Tables
646.8L	Gordon's Bay	WI DNR et al.	Yes		80	No	Yes	Yes
646.0R	Harpers Ferry Landing	IA DNR			80	No	Yes	Yes
645.9R	Babes Landing	Private	Yes	61	20	No	Yes	No
645.7R	Boardmans	Private		24	10	No	No	No
645.6R	Delphey Brothers	Private		54	15	No	No	No
645.4R	End-of-the-Line Resort	Private		54	10	No	No	No
644.0R	Lunds Camp	Private	Yes		4	Yes	No	No
643.0L	Frenchmans Landing	Private	Yes		10	Yes	Yes	No
642.0R	Nobles Landing	IA DNR			20	No	Yes	Yes
639.2L	Ambro Slough	USFWS			7	No	No	No
638.7L	Gremore- Ambro	WI DNR			20	No	No	No
638.7L	Lakeview Resort	Private	Yes		10	No	Yes	No
638.4L	Winneshiek Marina	Private	Yes	146	60	No	Yes	No
637.6R	Yellow River Access	IA DNR			3	No	No	Yes
636.6R	Clayton County Roadside	Clayton County			10	No	No	Yes
635.8L	W. Cedar Street Landing	Prairie du Chien	Yes		10	No	No	No
635.8L	Marina Ramp	Prairie du Chien	Yes		40	No	Yes	Yes
635.6L	Prairie du Chien Marina	Concession		85	30	No	Yes	No
635.8L	North Water St. Landing	Prairie du Chien	Yes		10	No	No	No
635.2L	Lawler Park	Prairie du Chien	Yes		50	No	Yes	Yes
634.7R	Marquette Landing	Marquette			20	No	Yes	No
634.6R	Casino Marina	Concession		68	50	No	Yes	No
633.7L	Lockwood St. Access	Prairie du Chien	Yes		8	No	No	No
633.7R	Boatels Marina	Private		65	10	No	Yes	Yes
633.4R	McGregor Landing	McGregor		15	10	No	Yes	No
633.3R	McGregor Harbor	Concession		50	20	No	Yes	No
633.3L	Big River Campsite	Private	Yes			Yes	Yes	Yes
629.6L	Glen Lake–Wyalusing S.P.	WI DNR	Yes		10	Yes	Yes	Yes
627.5L	Wyalusing Access	Wyalusing			50	No	Yes	Yes
627.3R	Sny Magill Access	IA DNR et. al.			20	No	No	No
624.8R	Clayton Landing	Clayton			5	No	No	No
624.7R	Bills Boat Landing	Concession		30	10	No	No	No
624.1L	Bagley Bottoms	FWS			5	No	Yes	No
622.4L	River of Lakes Resort	Private	Yes	190	20	Yes	Yes	Yes
621.7L	Jays Lake Landing	COE			20	No	Yes	Yes
618.3L	Glen Haven Access	Grant County		15	25	No	Yes	Yes
616.4R	Bussey Lake Access	DNR & Guttenberg			50	No	Yes	Yes
616.2R	Winegar	Concession		215	25	No	Yes	No
615.2R	Lock and Dam 10	COE & Guttenberg			10	No	Yes	Yes

III – HISTORY OF PROJECT

3-01. Authorization. The Lock and Dam No. 10 project was authorized on 3 July 1930 when the 71st Congress, second session, passed an act that modified the existing six-foot channel project in accordance with the plan for a comprehensive project to procure a channel of nine-foot depth, submitted in House Document No. 290. The nine-foot channel was to be achieved by construction of a system of locks and dams, supplemented by dredging.

3-02. Planning and Design. The lock and dam system is necessary to provide a nine-foot channel during low to moderate flows. As stated in House Document No. 137 of the 72nd Congress, 1st Session, Lock and Dam No. 10 was to be located on the left bank of the Mississippi River at the upper end of Cassville, Wisconsin. It was 1.1 miles below the mouth of the Turkey River at river mile 607. That put it in Rock Island District. It's location was not dictated by unusual river features so much as simply the need for a suitable lock location in that stretch of river. The location of the lock and dam changed when research determined that locating it in Cassville would do serious damage to Guttenberg, where the area lying between the business district and the higher land at the western side of the town was sufficiently low that it would be flooded by the pool of a dam located at Cassville. Therefore, the lock and dam was moved upstream to the right bank of the Mississippi River at river mile 615.1, in the town of Guttenberg. While the planning and design was performed by Rock Island District, the move upstream put the lock and dam in the St. Paul District and hence part of St. Paul District's lock and dam system.

The dam is operated to accommodate river flow conditions. In normal operation, all gates are partially open to allow water through. As the river flow increases or decreases, the gate openings are increased or decreased accordingly. If there were no flow in the pool, the pool would be level throughout its entire length. This is the "project pool" level that ensures a nine-foot channel depth. When there is flow, there is a slope to the water surface. Typically, the project pool level is held at the "primary control point" where project pool elevation intersects the ordinary high water profile and the pool would be operated on this "hinge" point. Lock and Dam No. 10 differs in operation from most pools in St. Paul District in that the primary control point is at the dam.

The elevation for primary control is 611.0 feet. This ensures ample and dependable nine-foot channel depth from the mouth of the Wisconsin River to the tailwater of Lock and Dam No. 9. As flow increases, the gates are opened to maintain primary control and a slope is imparted to the water surface profile. When the stage at Clayton reaches 611.8 feet, there is sufficient channel depth to allow for a drawdown at the dam. Therefore, Clayton becomes the "secondary control point". This occurs at a discharge of around 42,000 cfs. As flow continues to increase, the gates are opened to maintain a stage of 611.8 ± 0.2 feet at Clayton. This initiates the drawdown at the dam.

Note: As originally designed, maximum drawdown was established at 2.0 feet below project pool, or elevation 609.0 feet. It was reduced 1.0-foot or elevation 610.0 feet in August 1971. See Paragraph 3-04.c. 1971 Modifications for a complete explanation.

Maximum drawdown will occur when the discharge approaches 52,000 cfs. At this point, control transfers back to the dam. The pool is then held at the "tertiary control point" elevation of 610.0 ± 0.2 feet at the dam. As discharges increase, the gates are raised to maintain the maximum drawdown. As discharge continues to increase, eventually all the gates are raised above the water surface and open river conditions exist. This occurs at approximately 78,000 cfs discharge. At this time, the dam is said to be "out of control" and "open river conditions" exist.

The project design flood for Lock and Dam No. 10 was the flood of 1880. The design high water was elevation 620.1 feet with a flow rate of 226,000 cfs. The design of the dam called for less than one-foot of swell head at the design discharge. Hence the need for the 1,200-foot long ogee spillway which was constructed within the earthen dam. The spillway, which is located at Cassville Slough, has a crest elevation of 611.0 feet (i.e., Project Pool Elevation). In 1960, two slots, five feet long and three feet deep were cut into the spillway to provide aeration to backwater areas downstream of the dam.

The dam consists of a movable section with four roller and eight tainter gates, and an earthen dam. The configuration is slightly different than that typical for St. Paul District in that two of the tainter gates are located between the auxiliary lock and the roller gates. Because the roller gates were designed such that they can not be submerged, these two tainter gates can be. Therefore, the passage of ice and debris is through these two gates.

3-03. Construction. The Rock Island District designed and built Lock and Dam No. 10. Construction of the lock began on 23 February 1934 and was completed on 29 May 1935. Construction of the dam began on 11 February 1935 and was completed on 15 December 1936. The Rock Island District placed Lock and Dam No. 10 in operation on 26 November 1937, and approximately 2 years later, on 1 October 1939, control was transferred to the St. Paul District.

3-04. Related Projects. Lock and Dam No. 10 is one part of the 29 locks and dams on the Mississippi River necessary to maintain the nine-foot navigation channel between Minneapolis, Minnesota and St. Louis, Missouri. Thirteen of the 29 locks and dams are located in the St. Paul District. These include Upper and Lower St. Anthony Falls, as well as Lock and Dam Numbers 1 through 10.

3-05. Modifications to Regulation.

a. **1948 Modification.** The nine-foot channel depth was only important during the navigation season. Therefore, the pool could be drawn down far below project pool over the winter months whenever it was considered necessary. On 19 June 1948, an amendment was made to the act of Congress dated 10

March 1934, entitled "An act to promote the conservation of wildlife, fish and game, and for other purposes". The amendment was Public Law 697 and it prevented drawdown of the pools on the Mississippi River between Rock Island, Illinois and Minneapolis, Minnesota during the non-navigation season. The law is known as the "Anti-Drawdown Law". The law states that the "…dam structures shall generally operate and maintain pool levels as though navigation was carried on throughout the year."

b. 1960 Modification. Two slots, 5-feet wide by 3-feet deep, were cut into the crest of the 1,200-foot long spillway across Cassville Slough to provide aeration to backwater areas downstream of the dam. At project pool elevation (611.0 feet) a continuous flow of 135 cfs is maintained.

c. 1971 Modification. As originally designed, maximum drawdown was established at 2.0 feet below project pool, or elevation 609.0 feet. The Department of Natural Resources in the states of Iowa and Wisconsin, along with the Corps of Engineers Environmental Section, agreed that it would be more advantageous to have a more constant pool elevation. The towing industry was receptive to a higher pool level as well. Shoreline property owners in the lower pool also supported the idea of a more constant pool level. Therefore, in August 1971, pool drawdown was reduced to 1.0 foot, or elevation 610.0 feet (1912 adjustment). This remains today as the tertiary control elevation.

c. 1973 Modification. Discharge through the dam was reevaluated in 1973. This resulted in a slight change in the discharge per foot of opening on the roller and tainter gates. Therefore, there was a need to revise the Gate Regulation Schedule. Included in this revision was a redistribution of flow across the dam. The previous Gate Regulation Schedule had a more even flow distribution across the dam; however, to achieve that, the recommended tainter gate settings hugged the maximum allowable outflow velocity (4.5 feet per second). The new Gate Regulation Schedule, distributed flow across the dam based on a more equal distribution of outflow velocities.

d. 1975 Modification. Prior to 1975, the channel was over dredged in an effort to reduce the frequency of dredging. This stopped in 1975. While it did not have an impact on operation of the lock and dam, it did make channel tolerances a bit tighter.

e. 1983 Modification. In 1981, the Waterways Experiment Station began a study of the scour protection upstream and downstream of the Mississippi River dams and published their results in *Scour Protection for Locks and Dams 2-10, Upper Mississippi River*, Technical Report HL-87-4, April 1987. Since 1952, hydrographic surveys indicated that scour had occurred upstream and downstream of the dam. The purpose of the study was to develop a riprap design that would stabilize the existing conditions. Based on the preliminary results of the study, additional riprap protection was placed upstream and downstream of the dam in 1983. Because there may occasionally be a need to raise a gate for clearing debris, the riprap was designed to remain stable for extreme conditions under a very short duration. The design conditions were full open or half open single gate with normal pool and minimum tailwater. Before placement of the riprap, the maximum allowable gate openings were based on a flow velocity of 4.5 feet per second; however, for emergency purposes, it was permissible for flow velocities to go as high as 6.0 feet per second. Because of the additional channel stability, the maximum outflow velocity for routine gate movements was raised to 6.0 feet per second, and under emergency situations, this velocity may be exceeded for brief periods (i.e. 15 to 20 minutes). Therefore, a new Gate Regulation Schedule was developed showing the new maximum allowable gate openings (**Table 7-5**).

f. 1990 Modification. Part of the Guttenberg Waterfowl Ponds Habitat Project included the installation of a 275-foot long by 2-foot diameter gated steel pipe in the spillway. The upstream invert elevation of the pipe is 608.0 feet (1912 adjustment). At project pool elevation (611.0 feet) a flow of approximately 7 cfs is provided for raising the water surface elevation of the ponds from 605.0 feet to 608.0 feet (80 acre-feet) over a period of six days. Operation and maintenance of the project was transferred to the US Fish and Wildlife Service.

g. **1995 Modification.** Historically, winter regulation allowed for a tolerance of plus or minus 0.3-foot above or below the project pool elevation at the primary control point. This was to provide for delays in gate operations due to ice. The Water Level Management Task Force, which is a subcommittee of the River Resource Forum, is a multi-agency group that shares information and provides suggestions on river management (see **Section 9-02.e. River Resources Forum**). In 1995, the Task Force requested that Water Control hold the Mississippi River pools on the high side of the band during winter regulation on a trial basis. Therefore, starting in the winter of 1995, the primary control point at Lock and Dam No. 10 was maintained between elevations 611.0 feet and 611.3 feet. The purpose was to keep as much volume of water as possible in the backwater areas to avoid or delay dissolved oxygen depletion during the winter. The plan was implemented every year since and became official in the year 2000 when it was incorporated as a routine part of the operating plan.

h. **1997 Modification.** The motors that operate the lock miter gates were raised in 1997. Before this, the motors were pulled when the pool reached elevation 619.0 feet (1912 adjustment). Since the motors were raised, the lock does not go out of operation until the pool is at the top of the upstream miter gates at elevation 621.0 feet.

i. **2004 Modification.** Outflow measurements for the roller and tainter gates were taken between May and October 1998. The results published by Barr

Engineering Company in 1999 showed a shift in the discharge per foot for the roller and tainter gates. The largest shift occurs at high head differentials for the tainter gates and low head differentials for the roller gates. The new discharge ratings were found to not agree well with full river discharge measurements taken as part of the same study. However, the full river discharge measurements more closely matched the existing discharge rating curves and therefore the rating curves were not changed at this time. A check of roller and tainter gate end sill velocities necessitated minor modifications to the existing Gate Regulation Schedule. A new Gate Regulation Schedule (**Table 7-5**) was developed based on these findings.

3-06. Principal Regulation Problems.

a. Outdraft. An outdraft problem exists at Lock and Dam 10 for down-bound as well as up-bound tows. Signs are located at the end of the upper and lower guide walls to warn of outdraft when flows are above 46,000 cfs. The signs are circular, about three feet in diameter, and are orange in color. They are permanently mounted on a hinge, thereby allowing them to be swung out into view when necessary.

b. Zebra Mussels. Zebra Mussels are present at all St. Paul District locks and dams on the Upper Mississippi River. It is possible that they may foul the gage wells, concrete surfaces, and untreated metal surfaces such as the lock miter gates. Masses of dead zebra mussels could accumulate in the gate recesses, hindering operation. The St. Paul District developed a “Zebra Mussel Response Plan” in November 1997. There were five methods for short-term control identified for locks and dams. **Tables 3-1 and 3-2** show the possible problems and the recommended control techniques identified in the study.

Table 3-1 **Zebra Mussel Control Techniques**		
Code	**Method**	**Description**
A	Physical Removal	Removed by scraping, brushing, or high-pressure water or steam spraying.
B	Mollusicides	Primarily oxidizing biocides (chlorine) with possibility of periodic use of nonoxidizing biocides.
C	Thermal Treatments	Hot water, steam, or air injection periodically to kill adult and larval zebra mussels.
D	Dewatering Dislocation	Isolation of susceptible components from the river. Components removed from river if possible.
E	Replacement Components	Replacement components which can be easily removed should infestation occur.

Table 3-2 **Proposed Zebra Mussel Control Techniques for Locks and Dams**		
Component	**Potential Problem**	**Method**
Lock Walls	Heavy encrustations can be expected. Structural damage limited to abrasion during cleaning.	A,D
Gages	Occlusion of the pipe leading from the well to the River. Encrustation of level markings.	A,B,C,D
Thermometers	Encrustations could reduce reliability of readings.	A
Miter Gates	Increased corrosion of metal surface, paint deterioration, and unbalanced loading.	A,D
Bulkhead Slots	Accumulation along the sealing surfaces.	A,D
Lock Culverts	Reduced flow area and increased roughness could cause increased emptying and filling times.	A,D
Roller Gates	Increased gate weight and corrosion.	A,D
Side Seals	Accelerated deterioration of seals.	A,D,C,E
Tracks, Chains, Cables	Accumulation could prevent movement of roller gates. Metal and paint deterioration.	A,D

IV – WATERSHED CHARACTERISTICS

4-01. General Characteristics. At project pool elevation of 611.0 feet (1912 adjustment), the pool has a total surface area of 17,070 acres. The drainage area of Pool No. 10 totals 79,370 square miles in Minnesota, Wisconsin, and Iowa. The two major tributaries that flow into Pool No. 10 are the Yellow River with a total drainage area of 245 square miles and the Wisconsin River with a total drainage area of 11,700 square miles. The Yellow River enters the pool from the Iowa side of the Mississippi River and the Wisconsin River enters from the Wisconsin side. The Kickapoo River with a total drainage area of 762 square miles is tributary to the Wisconsin River. Its confluence is located approximately 16 miles upstream of the Wisconsin River confluence with the Mississippi River.

4-02. Topography. The reach where Lock and Dam No. 10 is located is oriented approximately north to south through a two-mile wide alluvial valley. The riverbed is at an elevation of approximately 590 feet above sea level (NGVD 1929). Steep bluffs rise 400 to 700 feet above the elevation of the river surface. Beyond the bluffs lies rolling farmland with occasional hardwood forest studded ravines. The Kickapoo River originates in Monroe County in southwestern Wisconsin and flows southwest through Vernon, Richland, and Crawford counties. The Kickapoo Valley is located in the “Driftless Area” of Wisconsin, which is an area that escaped the leveling effects of glaciers during the ice ages. As a result, the valley contains varied topography that includes narrow ridges and steep bluffs. The ridge crests have distinct round-tops with a width of 0.1 to 0.6 miles. The valley bottoms, which lie 300 to 400 feet below the uplands, vary in widths from 0.1 to 1.0 miles. The Kickapoo River empties into the Wisconsin River near Wauzeka, approximately 16 miles upstream of the junction of the Wisconsin River and the Mississippi River. The Master Water Control Manual for the Locks and Dams contains a description of the topography for the Upper Mississippi River basin.

The Wisconsin River is the largest river in Wisconsin and its 11,700 square mile watershed represents almost a quarter of the state's area. It rises in Lac Vieux Desert at the Wisconsin-Michigan Upper Peninsula border and flows southward, winding through heavily forested lands, agricultural lands, and the rolling hills and bluffs of southwestern Wisconsin to its confluence with the Mississippi River at Prairie du Chien, Wisconsin. The Wisconsin River basin is divided into three sections: the upper basin between the source at Lac Vieux Desert and Merrill, Wisconsin; the central basin between Merrill and Wisconsin Dells; and the lower basin between Wisconsin Dells to the confluence with the Mississippi River. The upper basin drains about 2,780 square miles and is predominantly flat glacial outwash with a gentle slope of 3.5 feet per mile and shallow depressions occupied by lakes or bogs. Vegetation is mostly deciduous or coniferous forest and boggy areas. Several impoundments exist along the main stem and tributaries that are used for water supply, recreation, and minimal hydropower. The central Wisconsin River basin drains about 5,050 square miles. Here, the river flows through predominantly flat to gently sloping terrain with a few isolated hills. Over fifty percent of the land is used for agriculture and there are still a number of large, boggy depressions throughout the basin. The remaining 4,450 square miles of drainage area comprise the lower basin. This area is hilly and mostly used for agriculture. The river meanders through the valley at an average slope of 1.5 feet per mile before discharging into the Mississippi River.

4-03. Sediment. Part of the nine-foot navigation plan authorized by Congress included periodic dredging of sediment. There are several sites within the Pool No. 10 navigation channel that require periodic dredging. Also requiring periodic dredging is the Wyalusing Slough Side Channel at the public boat launch. Any dredging downstream of Pool No. 10 is the responsibility of Rock Island District. All dredging above Lock and Dam No. 19 is the responsibility of the St. Paul District's Fountain City Boat Yard located at Fountain City, Wisconsin. As soon as the ice leaves the river, hydrographic surveys are made to get an early indication of channel conditions. After spring high water, surveys of the historic problem spots are performed. Equipment is lined up and a priority list is made. **Table 5-3** gives a summary of dredging in Pool No. 10 since 1970.

Table 4-1
Summary of Dredging Activity – 1970 through 2000

Cut Name	River Mile	Avg. Vol. Per Year	Avg. Vol. Per Job	Freq. of Dredging	Last Year Dredged
Hay Point	646.0-646.6	2,559	39,667	6 %	1972
Jackson Island	643.7-644.7	7,177	74,159	10 %	1981
Mississippi Gardens	642.7-643.4	5,695	88,278	6 %	1976
Prairie du Chien	635.0	3,385	104,932	3 %	1976
Wyalusing	627.0-629.0	1,104	34,217	3 %	1970
Wyalusing Slough Side Channel	627.9	1,123	34,824	3 %	1978
McMillan Island	618.4-619.6	15,746	34,867	45 %	1999
Upper Approach L/D 10	615.1-616.5	1,736	53,817	3 %	1973

4-04. Climate. The National Weather Service maintains temperature and precipitation records for Lock and Dam No. 10. Temperature and precipitation data shown in the following tables were taken from National Oceanic and Atmospheric Administration's *Climatological Data Annual Summaries*, for Guttenberg Lock and Dam 10, Iowa. The 30-year normal period used was 1970 to 2000. Pan evaporation data was collected at Lock and Dam No. 6, but stopped after 1997. Pool evaporation was estimated by assuming a pan coefficient of 0.7.

Table 4-2
30-Year Normal Monthly Temperature in Degrees Fahrenheit

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
16.6	21.9	34.6	48.6	60.5	69.8	73.9	71.5	62.9	51.7	37.0	22.7	47.6

Table 4-3
30-Year Normal Monthly Precipitation in Inches

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.88	1.05	1.93	3.02	3.48	3.95	4.22	4.04	3.47	2.34	2.01	1.36	31.75

Table 4-4 Pan and Pool Monthly Evaporation in Inches (Lock and Dam No. 6)								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Period of Record
Pan Evaporation	0.26	3.35	3.92	5.15	4.66	2.88	0.65	(1983 – 1997)
Pool Evaporation	0.18	2.35	2.74	3.61	3.26	2.02	0.46	(1983 – 1997)

Wind speed and direction are recorded each morning at Lock and Dam No. 10. While this information is valuable for the regulation of the dam, it is of little value for presenting monthly highest wind speeds and directions. The *Climatic Atlas of the United States* (June 1968) contains monthly Fastest Mile information for La Crosse, Wisconsin. Fastest Mile wind speeds are defined as the fastest speed at which wind travels one mile measured over one month. Fastest Mile wind speeds are typically obtained from a short period of time, usually less than two minutes duration. The Fastest Mile wind speeds presented in the Atlas were modified to time-dependent (1-hour) average wind speeds using procedures presented in the US Army Corps of Engineers' *Shore Protection Manual* (1984).

Table 4-5 Highest Monthly Wind Speed and Direction in MPH for La Crosse, WI												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Direction	NNW	WNW	NNW	SSW	E	NNW	N	N	SSW	WNW	S	NNW
Fastest Mile	35	36	40	50	58	60	36	46	36	38	46	43
1-Hour	29.5	30.3	33.3	41.0	46.8	47.2	30.3	37.9	30.3	31.8	37.9	38.1

Because of the bluffs along the river, winds tend to be channeled either up river or down river. The wind blowing across the pool surface exerts a horizontal force on the water surface and induces a surface current in the general direction of the wind. The horizontal currents induced by the wind essentially cause water to "pile up" on the downwind side, resulting in a water level rise downwind and a water level drop upwind. The change in water level is due to "wind setup". The rise in water can be estimated by (EM 1110-2-1414):

$$S = (U^2 F)/(1400 D)$$

S = Wind Setup (ft)
U = Wind Speed (mph)
F = Fetch Length (miles)
D = Average Depth over Fetch (ft)

The above equation neglects the time required for the full wind setup to occur. The stronger the wind, the more time required. While it is recognized that the relationship is not linear, a rule of thumb has been developed that seems to work quite well for the lock and dam pools. For each ten miles per hour of wind speed, figure the change in the pool level to be 0.1 feet. Therefore, a northern wind at 20 mph would cause a 0.2 feet rise in the water surface at the dam, and conversely, a southern wind of 10 mph would result in a lowering of the water surface at the dam by 0.1 feet.

4-05. Storms and Floods. High inflows from upstream as well an isolated storm over the Wisconsin River basin can produce flooding of the pool. The primary source of these high flows is snowmelt from the winter's accumulation of snowfall, especially when it is combined with high temperatures and high intensity rains. The magnitude of spring floods is also affected by the depth of frost in the ground at breakup time and the condition of the river channel. After construction of the Lock and Dam in 1936, the first significant flood event did not occur until the spring of 1951. On the 21st of April, the Mississippi River at Clayton crested at 8 feet above flood stage with a gage height of 23.0 feet (elevation 623.0 feet - 1912 adjustment). This stage was exceeded the following year. On the 24th of April 1952, the Clayton gage peaked at 23.15 feet with a peak pool gage elevation of 623.15 feet. Estimated discharge was 228,000 cfs. This remained the flood of record until 1965. **Table 4-5** gives a summary of peak elevations and discharges followed by a brief description of some of the larger events.

Table 4-6 Summary of Peak Stages/Elevations and Discharges					
Clayton, Iowa		**Lock and Dam No. 10**			
Date	Elev. ft (1912)	Date	Pool Ft (1912)	Tailwater ft (1912)	Discharge cfs
20-Apr-51	623.00	21-Apr-51	620.15	619.63	-
24-Apr-52	623.15	24-Apr-52	620.20	619.67	228,000
24-Apr-65	**627.40**	**24-Apr-65**	**624.24**	**623.65**	**308,000**
22-Apr-69	623.70	23-Apr-69	620.43	619.84	239,000
30-Jun-93	623.69	30-Jun-93	620.67	620.15	237,800
15-Apr-97	623.28	15-Apr-97	620.00	619.40	231,200
20-Apr-01	625.46	21-Apr-01	622.42	621.68	269,200

a. April - May 1965. Because of the magnitude of the snow-water content on the ground, forecasts and warnings of floods were issued by the Weather Bureau (now the National Weather Service). An advisory on the flood potential in the Upper Mississippi River basin was published as early as the 19th of March 1965. The forecast predicted a stage of 17.0 feet at Prairie du Chien, Wisconsin (flood stage is 18.0 feet), and 15.5 feet stage at Guttenberg, Iowa (flood stage is 15.0 feet) with a discharge of 166,000 cfs if normal precipitation and a snowmelt of more than three days occurred. The forecast cautioned that if rainfall of one inch should occur before or during the crest, the resulting crests would be near the 1952 level, with a stage of 21.0 feet at Prairie du Chien, and 19.7 feet at Guttenberg with a discharge of 225,800 cfs. Almost four inches of rain fell in the first two weeks of April. The Weather Bureau revised the forecast for Prairie du Chien, predicting a stage of 22.0 feet, and for Guttenberg, a stage of 21.0 feet and a discharge of 260,000 cfs. The forecasted discharge translated into a predicted elevation of 621.5 feet (1912 adjustment) at the dam. Based on this forecast, the earthen dike with a crest elevation of 624.0 feet was strengthened and raised to provide sufficient freeboard, and spillway abutments were protected by sandbags and riprap. Because the top of the lock walls are at elevation 624.0 feet, the central control station had to be ringed with sandbags.

The rapid increase of inflow began on the 1st of April when the discharge at Dam No. 10 rose from 30,000 cfs on this date to 70,000 cfs on the 5th of April. By this time the head at the dam had been reduced to less than one foot and the gates were removed from the water. The motors that operate the lock miter gates were pulled on the 19th of April and the lock was out of operation until the 4th of May. The Mississippi River crested at stage 25.38 feet at Prairie du Chien on the 24th of April. This was 7.38 feet above flood stage and was 4 feet higher than any flood crest ever recorded. The pool at Lock and Dam No. 10 crested on the 24th of April at elevation 624.24 feet with a peak flow of 308,000 cfs. The pool returned to secondary control (elevation 609.0 feet) on the 27th of June and the dam was put back into operation. The Wisconsin River peaked on the 18th of April with a discharge of 48,500 cfs at Muscoda. At the time of peak flow at Lock and Dam No. 10, the Wisconsin River discharge had dropped to 24,600 cfs. Damages in Prairie du Chien and Guttenberg were estimated at $900,000 and $255,000, respectively.

b. April 1969. The great amount of data showing heavy snowfall and high water equivalent of snow on the ground early in 1969 could lead to only one inescapable conclusion – high magnitude spring floods were inevitable in the upper Midwest. Fortunately in April as well as in March, precipitation was well below normal in the upper Midwest. Still, runoff produced high stages in Pool No. 10. At Praire du Chien, Wisconsin, more than 60 families were forced from their homes and others moved to the second story to get above the flood waters. The maximum discharge for the Wisconsin River was about 41,100 cfs as compared to about 44,600 cfs in April 1965. The peak discharge of the Mississippi River at Lock and Dam No. 10 followed the peak discharge of the Wisconsin River by seven days. When the Mississippi River peaked, the Wisconsin River was only contributing 18,000 cfs. The gage at McGregor, Iowa crested on 22 April at elevation 626.87 feet (1912 adjustment), over 5.5 feet above flood stage. The pool crested the next day at elevation 620.43 feet.

c. April 1997. The magnitude of the snow-water content on the ground indicated a high potential for flooding along the Upper Mississippi River. On the 13th of March, the National Weather Service outlook predicted a stage of 22.5 feet at McGregor, Iowa. On the 15th of April, McGregor crested at a stage of 22.50 feet (elevation 627.80 feet–1912 adjustment). Flood stage for McGregor is 16.0 feet. The pool at the dam crested on the 15th of April at elevation 620.0 feet. Peak discharge was over 231,000 cfs. The motors that operate the lock miter gates had been recently raised thus allowing the lock to remain open. The Wisconsin River at Muscoda peaked on the 10th of April with a stage of 7.94 feet (gage zero 666.77 feet NGVD 1929) and a discharge of 39,700 cfs. At the time of peak flow at Lock and Dam No. 10, the Wisconsin River discharge had dropped to 22,700 cfs.

d. April 2001. The National Weather Service's 2001 Spring Snowmelt Flood Outlook predicted minor to moderate flooding for Pool No. 10. This forecast was primarily due to the significant autumn precipitation the year before and the heavy winter snowfall. A less than ideal snowmelt followed by record breaking April precipitation resulted in producing the second highest flood stages in Pool No. 10. On April 20th at 1600-hours, the stage at McGregor, Iowa peaked at 23.75 (elevation 629.05 – 1912 adjustment) and was above flood stage from April 13th through May 18th. At Guttenberg, Iowa, the stage peaked on April 22nd in the early morning at 21.65 feet, and was above flood stage (15 feet) for the period of April 14th through May 16th. The pool at the dam crested on the 21th of April at elevation 622.42 feet. Peak discharge was over 269,000 cfs. The pool reached the closure elevation of 621.0 feet on 18th of April and did not fall below elevation 621.0 feet until the 25th of April. Additional rainfall resulted in a second crest of elevation 620.72 feet on the 4th of May. While the lock may have been operable before the 18th of April and after the 25th of May, the Coast Guard closed the river to navigation from the 9th of April to the 9th of May. Lock and Dam No. 10 was not reopened until the week of May 14th. By this time the pool had fallen to elevation 616.93 feet.

4-06. Runoff Characteristics. The mean annual discharge at Lock and Dam No. 10 is 49,800 cfs based on a period of record from 1960 to 2002. The following table shows the monthly average discharges.

Table 4-7
Monthly Average Flow in cfs – (Years 1960 to 2002)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
28,200	30,500	53,900	98,000	81,600	61,600	51,000	36,500	38,200	41,300	41,700	32,100

A maximum discharge of 308,000 cfs occurred at the dam on 24 April 1965 (**Table 4-5**). The lowest discharge of record was approximately 6,000 cfs during 1933. The lowest winter discharge recorded was 8,900 cfs on 3 December 1976. The minimum discharge during navigation season occurred with the drought of 1988 when the discharge got as low as 10,900 cfs on 7 July, and remained below 11,600 cfs from 5 July through the 10 July. A discharge-frequency curve for the Mississippi River at McGregor, Iowa is shown on **Figure 8-1**. The following table shows the discharge-duration at the dam.

Table 4-8
Discharge-Duration at Lock and Dam No. 10
Percent Time At or Above Indicated Discharge (Years 1972-2000)

Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
175,000			1.3	3.0	1.3	0.7	1.7		0.1	1.0			0.8
170,000			1.7	3.5	1.8	0.7	1.8		0.1	1.0			0.9
165,000			1.8	4.3	2.0	0.7	2.2		0.1	1.1			1.0
160,000			2.0	5.8	2.3	0.8	2.3		0.2	1.1			1.2
155,000			2.1	6.9	2.5	0.8	2.5		0.2	1.2			1.4
150,000			2.3	8.5	2.8	0.8	2.6		0.2	1.2			1.5
145,000			2.5	10.1	3.7	0.9	2.7		0.2	1.3			1.8
140,000			2.8	11.8	4.6	0.9	2.8		0.3	1.8			2.1
135,000			2.9	14.4	6.2	1.0	2.8		0.3	1.8			2.5
130,000			3.1	18.5	8.8	1.7	3.2		0.3	2.3			3.2
125,000			3.5	22.6	10.9	2.9	3.8		0.5	2.6			3.9
120,000		0.1	3.8	26.1	15.0	3.8	4.6		0.5	3.1			4.8
115,000		0.6	4.7	28.5	18.1	5.1	5.1		0.7	3.5			5.5
110,000		0.6	6.2	31.4	22.3	6.3	5.8	0.2	0.9	4.1			6.5
105,000		0.7	7.5	36.2	26.7	9.1	6.2	0.9	0.9	4.8	0.2		7.8
100,000		1.0	9.3	44.0	31.8	10.9	6.9	2.0	1.3	5.6	0.6	0.2	9.5
95,000		1.3	13.1	50.7	37.0	13.5	7.5	3.3	2.6	6.2	1.5	0.6	11.5
90,000		1.6	16.4	58.1	44.8	16.1	10.6	5.2	3.7	7.3	4.1	1.2	14.1
85,000		2.2	19.2	63.0	49.3	20.5	14.4	5.8	5.2	8.7	6.8	1.8	16.4
80,000		2.4	23.1	67.2	51.3	24.8	17.9	7.7	7.2	10.3	8.9	3.1	18.7
75,000		2.4	26.5	70.2	55.0	27.9	21.4	8.7	8.4	11.2	10.1	3.7	20.5
70,000		2.4	29.3	71.5	57.5	32.2	23.5	9.8	10.2	12.1	12.0	3.9	22.1
65,000		2.6	31.5	73.3	59.2	36.4	26.3	10.9	12.2	14.1	13.5	4.2	23.7
60,000		2.9	36.2	76.4	62.9	41.6	33.0	12.7	15.9	16.6	14.9	4.7	26.6
55,000	0.3	4.5	42.3	80.6	67.6	51.2	39.8	18.8	21.8	20.9	19.9	5.5	31.2
50,000	2.7	6.6	50.8	84.0	73.2	59.9	48.3	24.0	28.2	28.5	29.3	8.9	37.1
45,000	6.6	8.2	57.4	87.1	78.6	72.6	58.2	34.2	34.8	36.6	41.8	15.5	44.4
40,000	12.0	12.4	65.5	93.1	82.8	79.5	65.1	43.1	42.5	46.1	54.4	27.1	52.1
35,000	28.1	26.7	73.2	96.1	88.1	83.0	71.9	54.6	54.8	54.2	65.5	41.7	61.6
30,000	47.1	47.1	83.1	97.9	92.4	86.2	77.5	70.3	64.8	65.1	77.7	53.8	72.0
25,000	66.1	74.4	93.2	99.1	95.2	91.7	83.0	78.4	78.1	75.6	89.7	72.2	83.1
20,000	91.0	92.7	98.8	99.7	98.6	96.4	89.5	86.5	89.9	88.4	94.6	87.4	92.8
15,000	96.2	97.3	100.0	100.0	99.9	98.3	95.4	94.1	95.1	96.7	97.0	94.5	97.0
10,000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	99.9	100.0	99.6	99.9
5,000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Construction of the lock and dam greatly influenced stage-duration curves throughout the pool. Based on a period of record from 1972 to 2000, the following four elevation-duration tables were developed: (1) Lock and Dam No. 10 tailwater, (2) Lock and Dam No. 10 pool, (3) Clayton, Iowa secondary control point, (4) McGregor, Iowa gage. The tables indicate the percent of time the water surface is at or above the indicated elevation (1912 adjustment). Gage zero for the pool and tailwater gages is elevation 600.70 feet and 600.00 feet (1912 adjustment), respectively. The Clayton gage zero is elevation 600.00 feet (1912 adjustment) and the McGregor gage zero is elevation of 605.30 feet (1912 adjustment).

Table 4-9
Elevation-Duration, Lock and Dam No. 10 Pool
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
619.0			0.1	0.8	0.6	0.5	0.3						0.2
618.8			0.2	0.8	0.7	0.5	0.4			0.2			0.2
618.6			0.3	1.3	0.7	0.5	0.4			0.3			0.3
618.4			0.4	1.4	0.9	0.6	0.7			0.4			0.4
618.2			0.6	1.6	0.9	0.6	0.8			0.4			0.4
618.0			0.6	1.6	0.9	0.6	0.8			0.7			0.4
617.8			0.7	2.1	1.0	0.6	1.2			0.8			0.5
617.6			0.9	2.1	1.0	0.6	1.5			0.8			0.6
617.4			1.0	2.2	1.1	0.7	1.5			0.8			0.6
617.2			1.1	2.3	1.2	0.7	1.6		0.1	0.9			0.7
617.0			1.2	2.8	1.2	0.7	1.7		0.1	0.9			0.7
616.8			1.5	3.1	1.3	0.7	1.7		0.1	1.0			0.8
616.6			1.6	3.2	1.3	0.7	1.8		0.1	1.0			0.8
616.4			1.7	3.7	1.3	0.7	1.8		0.2	1.0			0.9
616.2			1.7	4.0	1.8	0.7	2.2		0.2	1.0			1.0
616.0			1.8	5.1	1.9	0.8	2.3		0.2	1.1			1.1
615.8			2.0	5.9	2.1	0.8	2.3		0.2	1.1			1.2
615.6			2.1	6.8	2.3	0.8	2.5		0.2	1.1			1.3
615.4			2.1	7.1	2.3	0.8	2.5		0.2	1.2			1.4
615.2			2.3	8.5	2.5	0.8	2.6		0.3	1.2			1.5
615.0			2.3	9.3	3.2	0.8	2.6		0.3	1.2			1.7
614.8			2.6	10.2	3.6	0.9	2.7		0.3	1.3			1.8
614.6			2.7	11.6	4.2	0.9	2.7		0.3	1.6			2.0
614.4			2.9	13.0	5.3	0.9	2.8		0.3	1.6			2.2
614.2			2.9	14.9	6.8	1.0	2.8		0.3	1.9			2.6
614.0			3.1	17.0	8.0	1.4	2.9		0.3	2.0			2.9
613.8			3.2	19.8	9.5	1.7	3.2		0.5	2.3			3.4
613.6			3.5	21.6	10.9	2.4	3.5		0.5	2.6			3.7
613.4			3.6	23.9	13.0	3.3	4.0		0.5	2.7			4.3
613.2			3.8	25.8	14.5	3.9	4.5		0.5	3.0			4.7
613.0		0.4	4.2	27.1	16.5	4.5	4.6		0.6	3.2			5.1
612.8		0.5	5.0	28.5	18.2	5.4	5.2		0.8	3.3			5.6
612.6		0.6	5.3	30.1	20.6	6.3	5.6		0.9	3.7			6.1
612.4		0.6	5.9	33.5	22.9	7.4	5.8	0.2	0.9	4.1			6.8
612.2		0.7	6.9	35.6	25.0	8.7	6.1	0.4	1.0	4.5	0.1		7.4
612.0		0.7	7.9	38.9	28.5	10.0	6.5	0.9	1.2	4.6	0.3		8.3
611.8		0.9	8.6	43.0	30.9	10.7	6.8	1.3	1.2	5.0	0.3		9.1
611.6		1.0	10.1	46.4	33.3	11.5	6.9	2.0	1.5	5.3	0.7	0.2	9.9
611.4	0.1	1.2	12.0	49.9	35.8	13.8	8.9	3.7	2.1	6.8	2.8	1.0	11.5
611.2	3.3	5.4	16.7	56.3	42.3	22.1	20.7	23.8	16.8	24.0	16.3	13.2	21.8
611.0	16.5	20.0	29.9	68.6	58.2	40.1	41.2	60.6	52.9	61.0	52.5	38.9	45.1
610.8	30.9	30.0	43.6	74.0	69.2	51.3	50.8	75.2	67.4	75.5	69.7	59.1	58.2
610.6	53.3	52.2	56.7	79.0	76.8	62.9	62.0	82.3	77.4	79.8	78.3	71.5	69.4
610.4	72.5	71.1	70.8	84.4	82.2	74.1	76.6	89.9	86.8	86.2	84.1	85.0	80.4
610.2	87.7	86.0	86.2	91.4	92.0	88.2	89.5	95.2	94.0	93.1	92.2	92.5	90.7
610.0	96.8	97.7	96.2	98.3	98.8	98.7	98.4	98.8	98.5	98.8	98.9	97.1	98.1
609.8	99.4	99.6	99.4	99.8	100.0	100.0	99.8	100.0	99.9	99.9	99.9	99.6	99.8
609.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4-10
Elevation-Duration for Clayton, IA
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
620.5			0.9	2.6	1.1	0.7	1.5		0.1	0.8			0.7
620.0			1.1	3.3	1.1	0.8	1.6		0.3	1.0			0.8
619.5			1.2	5.1	1.6	0.8	1.9		0.3	1.0			1.0
619.0			1.4	7.4	1.9	0.8	2.4		0.4	1.1			1.3
618.5			1.5	9.5	3.2	1.3	2.5		0.4	1.1			1.7
618.0			1.6	13.0	4.9	1.7	2.7		0.4	1.2			2.2
617.5			1.9	17.4	8.7	2.1	3.1		0.5	1.3			3.0
617.0			2.4	22.5	12.2	2.3	3.6		0.5	2.2			3.9
616.5	0.1		4.3	26.5	16.5	4.0	4.6		0.5	2.8			5.1
616.0	0.3	0.6	6.2	31.2	22.1	5.5	5.5		0.6	3.9		0.1	6.6
615.5	0.6	1.1	7.9	38.0	26.3	8.3	6.4	0.1	0.6	4.8	0.3	1.3	8.3
615.0	1.7	1.3	10.8	45.4	32.8	10.9	7.8	1.6	1.6	5.9	0.5	2.0	10.5
614.5	1.9	2.6	15.3	51.9	39.8	14.1	8.6	3.2	2.5	7.4	1.1	3.5	13.1
614.0	4.2	3.8	19.6	57.2	48.5	18.1	12.2	5.0	5.2	9.2	5.1	5.6	16.6
613.5	8.5	6.2	25.3	65.0	52.8	25.2	20.7	7.7	8.3	10.9	7.4	8.7	21.1
613.0	15.0	12.6	35.2	70.5	58.3	36.8	29.7	11.7	14.8	14.5	11.5	12.8	27.6
612.5	23.1	20.9	46.5	76.4	68.0	52.6	41.8	22.0	22.7	25.9	23.5	22.4	37.9
612.0	39.4	38.6	65.0	85.4	81.8	75.9	60.8	43.3	44.1	48.4	51.2	46.3	57.4
611.5	69.9	65.5	89.5	97.0	92.9	91.2	85.4	77.1	74.4	77.8	84.6	79.5	82.5
611.0	91.4	94.3	98.4	100.0	100.0	100.0	99.9	99.6	99.8	97.6	99.8	97.3	98.3
610.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4-11
Elevation-Duration for McGregor, IA
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
624.0			0.9	2.3	1.1	0.7	1.1		0.1	0.8			0.6
623.5			1.3	2.9	1.2	0.8	1.5		0.1	0.9			0.7
623.0			1.3	4.0	1.3	0.8	1.7		0.2	1.0			0.9
622.5			1.8	4.8	1.6	0.8	2.2		0.3	1.0			1.1
622.0			2.0	7.4	2.2	0.9	2.5		0.3	1.1			1.4
621.5			2.2	9.1	2.9	0.9	2.6		0.3	1.2			1.6
621.0			2.7	11.8	4.3	0.9	2.7		0.5	1.6			2.1
620.5			3.1	15.9	6.9	1.5	2.9		0.5	1.9			2.7
620.0			3.3	20.9	9.6	2.3	3.6		0.5	2.6			3.6
619.5			3.8	25.9	13.2	3.9	4.5		0.5	2.9			4.6
619.0			4.9	30.5	17.5	5.2	5.1		0.8	3.2			5.6
618.5		0.5	6.3	35.9	23.1	7.6	6.1	0.1	1.0	4.0		0.6	7.2
618.0		1.0	7.8	42.2	29.8	9.4	6.6	1.1	1.2	4.7	0.3	1.0	8.8
617.5	0.8	1.4	10.3	50.2	35.7	11.5	7.1	2.2	1.6	5.3	0.6	2.2	10.8
617.0	1.4	1.7	14.6	56.0	41.9	14.7	9.3	3.6	3.6	6.8	2.5	3.5	13.4
616.5	2.0	1.9	18.5	61.7	47.4	19.4	12.8	4.8	5.1	7.9	5.4	5.7	16.2
616.0	2.2	2.5	23.9	66.9	51.3	23.7	17.7	7.1	6.8	9.5	7.9	8.5	19.1
615.5	5.7	3.6	30.8	71.4	54.6	29.4	22.6	8.9	8.7	11.1	10.6	12.0	22.6
615.0	9.9	7.2	39.4	75.3	58.8	37.9	30.0	10.7	13.7	13.6	13.5	16.6	27.4
614.5	16.4	12.1	47.2	77.9	63.7	45.9	36.4	14.7	19.1	18.0	16.4	22.3	32.7
614.0	25.6	23.9	57.4	82.1	70.2	58.2	43.7	22.1	25.1	24.3	27.2	33.3	41.2
613.5	41.6	36.2	68.6	87.6	77.0	68.7	52.1	31.0	32.8	36.6	42.3	45.1	51.7
613.0	55.4	53.1	82.1	93.0	83.2	79.4	64.0	43.7	43.2	48.9	62.9	63.0	64.4
612.5	73.0	80.6	91.7	97.4	90.1	84.0	75.4	63.9	60.8	64.7	77.2	79.0	78.1
612.0	85.3	91.9	96.2	99.0	94.8	90.2	83.9	80.0	83.1	81.1	90.5	88.0	88.6
611.5	96.7	96.8	99.0	100.0	99.7	99.0	98.2	96.2	96.0	97.4	98.7	95.7	97.8
611.0	100.0	98.8	99.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9

Table 4-12
Elevation-Duration, Lock and Dam No. 10 Tailwater
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
616.5			1.3	2.9	1.2	0.7	1.7		0.1	0.9			0.7
616.0			1.6	3.3	1.3	0.7	1.8		0.1	1.0			0.8
615.5			1.8	5.2	2.0	0.8	2.3		0.2	1.1			1.1
615.0			2.1	6.9	2.3	0.8	2.5		0.2	1.2			1.3
614.5			2.3	9.5	3.3	0.8	2.6		0.3	1.2			1.7
614.0			2.9	12.3	5.1	0.9	2.8		0.3	1.6			2.2
613.5			3.1	17.7	8.3	1.6	3.0		0.5	2.1			3.0
613.0			3.7	22.9	12.1	3.3	4.0		0.5	2.6			4.1
612.5		0.4	4.2	27.7	16.8	4.8	4.8		0.6	3.2			5.2
612.0		0.6	5.7	32.8	22.6	6.9	5.8	0.2	0.9	4.0			6.6
611.5		0.9	8.0	38.9	28.6	10.2	6.6	1.2	1.2	4.9	0.3	0.1	8.4
611.0		1.3	11.8	49.3	35.5	12.6	7.2	2.6	1.7	5.9	1.2	0.3	10.8
610.5		1.5	16.4	57.2	44.3	16.2	9.9	5.0	3.6	7.5	4.0	1.1	13.9
610.0		2.1	19.9	63.6	49.6	21.2	14.7	6.1	5.4	9.1	7.2	2.0	16.8
609.5	0.4	2.6	24.9	68.9	53.0	25.8	18.9	8.1	7.7	10.6	9.2	3.4	19.5
609.0	1.2	3.4	30.8	71.6	56.4	31.6	23.5	9.2	10.0	11.7	11.6	5.4	22.3
608.5	3.1	5.1	36.0	75.2	59.7	36.7	30.3	10.6	13.7	13.9	14.4	8.3	25.6
608.0	8.7	7.9	42.2	77.1	64.2	44.8	34.9	13.8	18.7	17.5	18.2	12.6	30.1
607.5	14.1	12.0	50.1	81.4	68.9	53.1	40.9	19.7	22.0	20.8	23.5	17.4	35.4
607.0	26.4	22.2	57.8	83.3	73.0	59.9	48.2	23.6	27.0	29.3	30.7	27.1	42.4
606.5	33.5	31.2	66.0	86.7	77.9	70.0	54.4	30.7	33.0	35.4	41.3	33.0	49.5
606.0	45.3	40.6	73.3	91.2	81.3	77.2	62.6	39.5	38.2	41.9	52.5	41.7	57.2
605.5	55.3	55.6	83.4	94.5	84.8	81.2	68.3	49.2	48.3	51.2	62.2	52.2	65.5
605.0	69.7	82.4	90.9	97.2	90.8	84.4	74.2	63.6	59.1	61.4	73.5	67.6	76.2
604.5	84.8	91.5	95.8	98.6	93.1	87.8	80.0	74.6	71.8	71.0	86.0	77.8	84.3
604.0	95.3	95.5	99.3	99.5	96.9	93.1	85.2	81.3	86.8	82.0	93.5	88.6	91.4
603.5	99.8	99.9	100.0	100.0	99.6	98.3	93.7	93.3	94.5	96.0	96.7	96.6	97.3
603.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.3	100.0	99.9

At a flat pool elevation of 611.0 feet (project pool), the storage volume in Pool No. 10 is 59,400 acre-feet. However, at moderate flows, there is a slope to the flowline that allows for a one-foot drawdown at the dam. A study of flood profiles shows at least two distinct slopes in the flow lines (see **Figure 8-3**). Therefore, storage volume for the pool was broken into two reaches. The two slopes intersect at about river mile 633.6 near the McGregor gage site. **Tables 4-12** and **4-13** can be used to determine the storage volumes in each reach for various elevations. Assuming an elevation of 610.0 ft at Lock and Dam No. 10, elevation 616.0 ft at the McGregor gage, and elevation 619.0 at the tailwater of Lock and Dam No. 9, the approximate volume of Pool No. 10 would be 105,200 acre-feet (i.e., 52,400 + 52,800 acre-ft). A flow rate of approximately 53,000 cfs would result in a daily exchange in storage. A relationship of storage to discharge is shown on **Plate 4-1**.

Table 4-13
Storage Volume of Pool No. 10 in 1,000 Ac-Ft
Between McGregor, IA and Tailwater of Dam No. 9

TW Elev at Dam 9	Elevation at McGregor, IA																				
	625	624	623	622	621	620	619	618	617	616	615	614	613	612	611	610	609	608	607	606	605
627	114	110	107																		
626	109	106	102	99																	
625		101	98	95	91																
624			94	90	87	84															
623				86	82	79	76														
622					79	75	72	69													
621						71	68	66													
620							64	62	59	57											
619								58	56	53	50										
618									51	49	46	44									
617										46	43	41	38								
616											40	38	36	33							
615												35	33	31	29						
614												32	30	28	26	24					
613													28	23	23	20	19				
612														23	21	19	17	15			
611															19	17	15	13	12		
610																	13	11	11	8	
609																		10	8	7	6

Table 4-14
Storage Volume of Pool No. 10 in 1,000 Ac-Ft
Between McGregor, IA and Pool of Dam 10

Pool Elev at Dam 10	**Elevation at McGregor, IA**																				
	627	626	625	624	623	622	621	620	619	618	617	616	615	614	613	612	611	610	609	608	607
619		128	124	120	115																
618		124	120	116	111	107															
617			116	112	108	104	100														
616				107	103	99	95	91													
615					99	94	90	86	82												
614						91	87	83	79	75											
613							82	79	75	71	67	63	60								
612									71	67	63	59	56	53	49						
611										63	59	56	52	49	46	43	41				
610											56	52	49	46	43	40	37	35			
609												49	46	43	40	37	35	32			
608												46	42	40	37	34	32	29			
607													40	37	34	31	29	27			
606														34	31	29	26	24			
605														31	29	27	24	22	20		
604															27	24	22	20	18	17	
603																23	20	18	17	15	13
602																	19	17	15	13	12

4-07. Water Quality. The St. Paul District does not collect water quality information for Pool No. 10. However, as an element of the Environmental Management Program (EMP), the Corps of Engineers oversees the Long Term Resource Monitoring Program (LTRMP) of the Upper Mississippi River System. The LTRMP was implemented to provide decision makers with the information needed to maintain the Upper Mississippi River System as a viable multiple-use large river ecosystem. The LTRMP is being implemented by the US Geological Survey (USGS) in cooperation with the states of Illinois, Iowa, Minnesota, Missouri and Wisconsin with guidance and overall program responsibility by the Corps of Engineers.

4-08. Channel and Floodway Characteristics. The top of the lower lock sill elevation at Lock and Dam No. 9 is elevation 598.0 feet and the top of the upper lock sill elevation at Lock and Dam No. 10 is elevation 596.0 feet. Therefore, there is a 2.0-foot drop in sill elevation along the pool, which has a length of 32.8 miles as measured along the navigation channel. The navigation channel is 300 feet in width in the straight stretches, and varies from 300 feet to 550 feet in the bends. The line of navigation is shown on **Plates 2-4** through **2-8**.

4-09. Upstream Structures. Lock and Dam No. 9 is located 32.8 miles upstream of Lock and Dam No. 10. The drainage area above Lock No. 9 is 66,610 square miles. The lock and dam system continues upstream to the Upper St. Anthony Falls Lock and Dam located in Minneapolis, Minnesota.

4-10. Downstream Structures. Lock and Dam No. 11 is located 32.1 miles downstream of Lock and Dam No. 10. The drainage area above Lock No. 11 is 81,600 square miles. The lock and dam system continues downstream to Lock and Dam No. 27 in St. Louis, Missouri; however, St. Paul District terminates with Lock No. 10.

4-11. Economic Data. Pool No. 10 lies on the Iowa-Wisconsin border. Allamakee County and Clayton County lie on the western side and Crawford and Grant Counties lie on the eastern side. Based on the US Census Bureau, county populations have increased slightly with the exception of Clayton County, Iowa.

Table 4-15
County and City Populations Near Pool No. 10

	1990	2000	Difference	Change
County				
Allamakee, IA	13,855	14,675	820	5.9 %
Clayton, IA	19,054	18,678	-376	-2.0 %
Crawford, WI	15,940	16,897	957	6.0 %
Grant, WI	49,264	49,320	56	0.1 %
City/Town				
Clayton, IA	41	55	14	34.1 %
Guttenberg, IA	2,257	1,987	-270	-12.0 %
Harpers Ferry, IA	284	330	46	16.2 %
Marquette, IA	479	421	-58	-12.1 %
McGregor, IA	797	871	74	9.3 %
Bagley, WI	306	339	33	10.8 %
Glen Haven, WI	548	490	-58	-10.6 %
Prairie du Chien, WI	5,659	6,018	359	6.3 %
Wyalusing, WI	364	370	6	1.6 %

The following table gives a break down of the employment by industry. The data were taken from the US Census Bureau's 1997 Industry Report.

Table 4-16
Employment by Industry – Counties on Pool No. 10 (1997)

Industry	Allamakee	Clayton	Crawford	Grant
Manufacturing	1,505	1,538	2,252	2,996
Wholesale Trade	512	335	118	613
Retail Trade	652	670	915	2,310
Real Estate, Rental, Leasing	24	20	20-99	126
Professional, Scientific, Tech Services	62	66	38	298
Admin & Support, Waste Management	23	80	131	215
Education Services	1-19	NA	NA	9
Health Care & Social Services	159	500-999	590	969
Arts, Entertainment & Recreation	20-99	33	28	101
Accommodations & Food Services	293	266	614	1,431
Other Services	82	78	87	331
Totals	3,313-3,331	3,586-4,085	4,793-4,872	9,399

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. The regulation and proper operation of the dam site requires the collection and evaluation of several hydraulic and hydrologic parameters. The Corps of Engineers (COE), US Geological Survey (USGS), and the National Weather Service (NWS) are involved in the data collection network. The secondary control point for Pool No. 10 is located on the Mississippi River at Clayton, Iowa at river mile 624.7 (**Plate 5-1**). The gaging station is located down a driveway below the Boat Landing Restaurant in the town of Clayton, and is housed inside a metal walk-in style shelter that has AC power (**Figure 5-1**). The site is a Data Collection Platform (DCP). It has a Sutron 8210 data recorder with GOES telemetry and voice modem, which is owned by the USGS. The GOES telemetry allows communication with the satellite system that provides hourly water surface elevations to Water Control. The voice modem allows telephone communication with the gage to obtain an instantaneous water surface elevation. There are two sensors at this site, owned by the COE. One is a Sutron Accubar sensor and the other is a Design Analysis H-310 pressure transducer with a water temperature gage. The gage is maintained by the Iowa USGS through a cooperative agreement with the COE (i.e. the co-op program).

An additional gage on Pool No. 10 is located at McGregor, Iowa, at river mile 633.5 (**Plate 5-1**). The gage is situated on the riverward side of the railroad tracks at the upstream side of the City Park, approximately 0.1 miles upstream of the boat landing in the City of McGregor (**Figure 5-2**). This station is housed in a concrete, AC powered walk-in style shelter on top of a concrete stilling well. It is a DCP with a Sutron 8210 data recorder, GOES telemetry, and voice modem owned by the USGS. The gage is owned maintained by the Iowa USGS through the co-op program. A tipping bucket mounted on the roof is owned and maintained by the COE.

Figure 5-1. Clayton Gage.

Figure 5-2. McGregor Gage.

The biggest tributary to the pool is the Wisconsin River. A gage site was already established on the Wisconsin River at Muscoda, approximately 39 miles upstream of the mouth (**Plate 5-1**). While the gage was easily outside the influence of any backwater effect from the Mississippi River, it also did not include a significant portion of the basin. Therefore, an additional gage was established at on the Kickapoo River in 1933. The Kickapoo River enters the Wisconsin River at about river mile 15 (**Plate 5-1**). The gage site was located 18.6 miles upstream of the mouth near the town of Steuben. The drainage basin above Muscoda is 10,400 square miles. The drainage area above Steuben is 678 square miles. The combined discharge from these two gage sites comprises the bulk of the basin. The USGS publishes discharges for each site.

The Kickapoo River gage is housed in a metal walk-in style shelter on the right bank at the upstream corner of the town road bridge at Steuben (**Figure 5-3**). The site is a DCP. It is equipped with a Campbell Scientific CR-10 data logger, a Stevens A-35 recorder, voice modem, and a Sutron Accubar sensor.

The equipment is battery driven which is recharged through the solar panel located on the roof. The period of record is from May 1933 to the current year. Gage zero is elevation 657.0 feet (NGVD 1929). The equipment is owned by the COE; however, it is maintained by the Wisconsin USGS through an annual cooperative (co-op) program. There is a wire weight gage on the upstream side of the bridge near the gage, which is owned and maintained by the USGS. A tipping bucket rain gage was added to the site in June 2002. It is owned and maintained by the COE.

Figure 5-3. Kickapoo River Gage at Steuben, Wisconsin

The Wisconsin River gage is located approximately 100 feet downstream from the State Highway 80 Bridge, 1.0 mile north of the town of Muscoda, Wisconsin (**Plate 5-1**). The gage house is a metal walk-in style shelter (**Figure 5-4**). It is a DCP and contains a Campbell CR-10 data logger, Sutron Accubar sensor, and a voice modem. The equipment is owned by the COE; however it is maintained by the Wisconsin USGS through a cooperative agreement. Gage zero for the gage is elevation 666.77 feet (NGVD 1929).

The period of record extends from October 1913 to the current year. A wire weight gage, owned and maintained by the Wisconsin USGS, is located on the Highway 80 Bridge. The COE attached a tipping bucket rain gage to the gage site in June 2002. It is owned and maintained by the COE.

Figure 5-4. Wisconsin River Gage at Muscoda, Wisconsin

The COE operates and maintains the pool and tailwater gages at the lock. These gage houses are unique to the St. Paul District in that they are not the standard “walk-in” style. The gages are located in “dog house” style shelters on the upper and lower guide walls about 500 feet from the lock chamber (**Figure 5-5**). The tailwater gage is a forecast point for the NWS (i.e. Guttenberg, Iowa). The tailwater elevation is important to the NWS as well as the Rock Island District (MVR). Therefore, in 1999 a DCP was installed. It consists of a Sutron 8200 data logger with GOES Telemetry, an air temperature sensor, and a Design Analysis H-310 pressure transducer. The COE added a tipping buck at the site in June 2002. All equipment is owned by the COE.

Figure 5-5. Lock and Dam 10 Tailwater Gage House

In addition to the DCP at the tailwater, there is also a stilling well gage. In fact, both the pool gage and the tailwater gage have stilling wells. A tape attached to a float wraps around an encoder that is attached to a Type PO Transmitter (**Figure 5-6**). The elevation can be read from the tape or it can be read directly through the viewing window located on the transmitter. Staff gages are located within the well to verify the gage reading.

Figure 5-6. Pool Gage – Type PO Transmitter

Both of the Type PO Transmitters report their elevations to two Stevens PAV-C Recorders located in the basement of the central control station (**Figure 5-7**). These strip charts act as a permanent record of the pool and tailwater elevations. The charts are periodically compared with the digital reading to ensure quality of the record. Once a year the charts are mailed into Water Control where they are periodically microfilmed. Water Control provides replacement charts. Note that the location of the Stevens Recorders proved to be quite inconvenient for site staff. Therefore monitors were provided on the first level of the central control station.

Figure 5-7. Stevens PAV-C Strip Chart Recorders

Additional gage types at the lock and dam include a water temperature sensor, reading in degrees Fahrenheit, located in the upper ladder recess and an anemometer which is located on the top of the radio tower near the central control station. The water temperature and the wind speed and direction are all electronically transmitted to the central control station. Site personnel are responsible for the maintenance of this equipment. The site is equipped with a measuring rod for snow depth and a snow tube and scale for determining snow-water content. Site personnel maintain the snow measuring equipment; however, Water Control is responsible for providing any replacement equipment. There is a standard 8-inch precipitation gage installed at the site. Data types and equipment are listed in **Table 5-1**.

Table 5-1
Hydrometeorological Stations

Location	Data Type	Equipment	Notes
Mississippi River at Clayton, Iowa	Water Surface Elevation Water Temperature	Sutron 8210 Data Recorder Design Analysis H-310 Digital Thermometer Sutron Accubar Sensor GOES Telemetry Voice Modem Staff Gage	Gage Zero: 600.00 (1912) NWS ID: CLAI4 Maintained by USGS Lat: 42^o 54" 13' N Long: 91^o 08" 42' W Two Gage Types
Mississippi River at McGregor, Iowa	Water Surface Elevation Precipitation	Sutron 8210 Data Recorder Stilling Well Staff Gage GOES Telemetry Voice Modem Tipping Bucket	Gage Zero: 605.30 (1912) Flood Stage: 16.0 ft NWS ID: MCGI4 Lat: 43^o 01" 29' N Long: 91^o 10" 21' W Maintained by USGS
Kickapoo River at Steuben, WI	Stage Precipitation	Campbell CR-10 data logger Stevens A-35 recorder Sutron Accubar Sensor GOES Telemetry Voice Modem Tipping Bucket Wire Weight Gage	Gage Zero: 657.0 (1929) Flood Stage: 12.0 ft NWS LI: STEW3 Lat: 43^o 10" 58' N Long: 90^o 51" 30' W Maintained by USGS
Wisconsin River at Muscoda, WI	Stage Precipitation	Campbell CR-10 data logger Sutron Accubar Sensor GOES Telemetry Voice Modem Tipping Bucket Wire Weight Gage	Gage Zero: 666.77 (1929) Flood Stage: 9.0 ft NWS LI: MUSW3 Lat: 43^o 11" 54' N Long: 90^o 26" 26' W Maintained by USGS
Lock & Dam No. 10 Upper Guide wall	Pool Elevation	Stevens A35 Recorder Stilling Well Type PO Transmitter Staff Gage	Maintained by COE
Lock & Dam No. 10 Lower Guide wall	Tailwater Elevation Air Temp	Sutron 8200 data logger Design Analysis H-310 GOES Telemetry Air Temperature Sensor Stevens A35 Recorder Stilling Well Type PO Transmitter Staff Gage	Two Gages Types NWS LI: GTTI4 Gage Zero: 600.0 ft (1912) Lat: 42^o 47" 05' N Long: 91^o 05" 42' W Maintained by COE
Lock & Dam No. 10 Central Control Station	Snow Depth & Water Content	Snow Rod Snow Tube Scale	Water Control Provides Replacement as Needed.
Lock & Dam No. 10 30-ft Radio Tower	Wind Speed & Direction	Anemometer Wind Direction Sensor	Maintained by site personnel.
Lock & Dam No. 10 Upper Ladder Recess	Water Temperature	Water Temperature Sensor	Electronically Transmitted to Lock House.
Outside the Central Control Station	Precipitation	Standard 8-inch Rain Gage	Replacement by Water Control Gage Crew.

b. **Reporting**. There are six gage sites associated with the operation of Lock and Dam No. 10. They are the pool and tailwater, McGregor and Clayton on the Mississippi River, Steuben on the Kickapoo River, and Muscoda on the Wisconsin River. Pool and tailwater elevations are reported to Water Control by site personnel every four hours using a remote computer terminal and the "Secure CRT" program. As the data comes into Water Control, discharge is automatically calculated and reported to a Data Storage System (DSS) file. Each day at 0600-hours, site personnel call the voice modems at the McGregor and Clayton gage sites and report the water surface elevations. These data are stored on the electronic Daily Logsheet in Water Control. Hourly DCP gage readings from McGregor, Clayton, Steuben, and Muscada are reported to Water Control through a satellite system. The DCP sends a signal to the US Geostationary Operational Environmental Satellite (GOES). The GOES satellite sends the signal to a Direct Readout Ground Station (DRGS) at Wallops Island Virginia. The data is reformatted and sent to the Domestic Communication Satellite (DOMSAT), which transmits the data to the DOMSAT Receive Station (DRS) located at the St. Paul District Office. This data is available from the Water Control web site at www.mvp-wc.usace.army.mil.

Transmission Path of DCP Data

```
                GOES                    DOMSAT
              ↑      ↓               ↑          ↓
            ↑          ↓           ↑              ↓
          ↑              ↓       ↑                 ↓
Gage → DCP                 DRGS                    DRS→ Water Control
```

Site personnel also report the gate settings on 4-hour intervals. Water Control automatically computes the discharge based on gate openings and the pool and tailwater elevations. When the gates are out of the water, the tailwater rating curve is used. Discharge values can be obtained from the Water Control web site. Other data reported to Water Control include water temperature (daily), max-min air temperature (daily), precipitation (daily), air temperature (8-hour), and wind speed and direction (8-hour).

During the winter months, percent of ice coverage over the lower pool and upper tailwater, ice thickness (observed), snow depth, and snow-water content (all in inches) are reported to Water Control once a week on Sundays. This information is available from the Water Control web site.

The Stevens PAV-C strip charts are mailed to Water Control every year where they are then periodically microfilmed.

c. **Maintenance.** All of the equipment at the lock and dam is owned and maintained by the Corps of Engineers (COE). The pool and tailwater gages are maintained the Water Control Gage Crew. Site personnel maintain the water temperature sensor, thermometer, precipitation gage, anemometer, and the snow measuring equipment. Water Control provides replacement as necessary for the precipitation gage, anemometer, and snow measuring equipment. The US Geological Survey (USGS) maintains the gages at Clayton, McGregor, Steuben, and Muscoda in cooperation with the COE. The Gage Crew provides emergency backup. Dam personnel maintain the Stevens PAV-C strip chart recorders with the Gage Crew used as a backup if necessary.

5-02. Water Quality Stations. There are no water quality stations in Pool No. 10; however, site personnel may be asked, on occasion, to assist district office personnel or contractors to collect water samples and/or water quality measurements in the project area. While not in Pool No. 10, there is a water quality monitoring station on the Wisconsin River at Muscoda that is operated and maintained by the USGS.

5-03. Sediment Stations. The Corps of Engineers contracts with the Iowa US Geological Survey (USGS) to collect suspended sediment data on the Mississippi River at McGregor. In addition, the Wisconsin USGS has collected sediment data on the Kickapoo and Wisconsin Rivers. **Table 5-2** gives the dates and locations.

Table 5-2 Sediment Data Collection Sites			
Location	**River**	**USGS Gage #**	**Sampling Time Period**
McGregor, IA	Mississippi River	05389500	1976 to 2004
Ontario, WI (Hwy 33)	Kickapoo River	05407470	1973
Ontario, WI	Kickapoo River	05407500	1973 to 1977
Rockton, WI	Kickapoo River	05407920	1972 to 1977
La Farge, WI	Kickapoo River	05408000	1971 to 1978
Soldiers Grove, WI	Kickapoo River	05409500	1974
Gays Mills, WI	Kickapoo River	05410000	1971 to 1977
Steuben, WI	Kickapoo River	05410500	1965 to 1976
Rainbow Lake, WI	Wisconsin River	05391000	1973
Merrill, WI	Wisconsin River	05395000	1973
Rothschild, WI	Wisconsin River	05398000	1976
Wisconsin Dells, WI	Wisconsin River	05404000	1973 to 1976
Muscoda, WI	Wisconsin River	05407000	1964 to 1994

The Corps of Engineers funds the McGregor site. **Figure 5-7** show the total annual suspended sediment load and average annual suspended sediment concentration for the years 1976 through 2002.

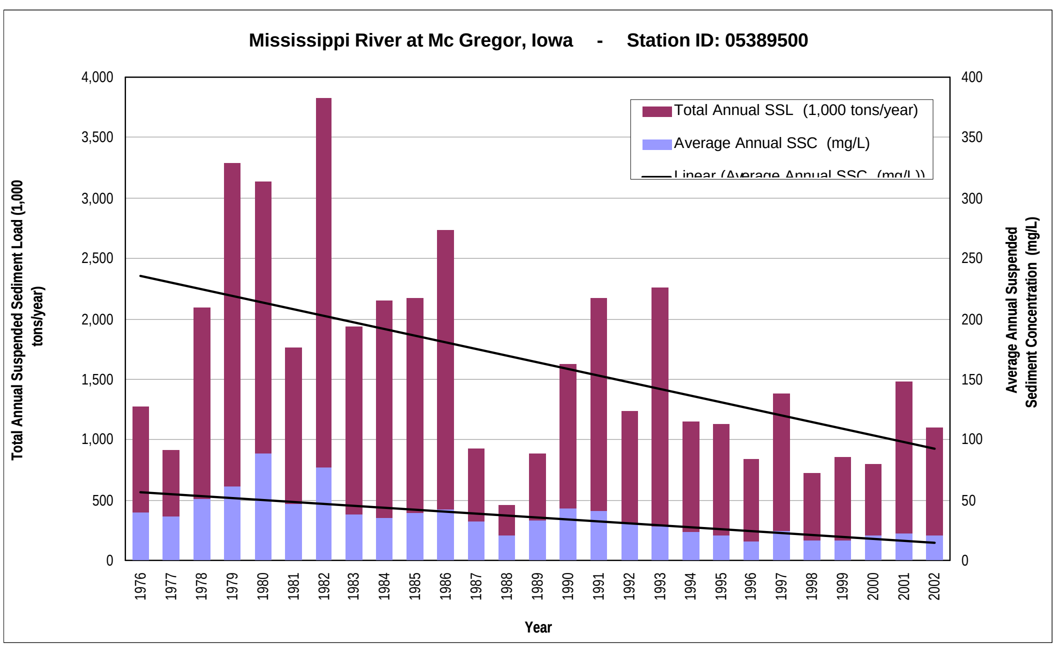


Figure 5-7. Suspended Sediment Load at McGregor, Iowa

5-04. Recording Hydrologic Data. An operators log book containing pool and tailwater elevations, roller and tainter gate settings, air temperature, precipitation, water surface elevations at McGregor and Clayton, Iowa, maximum and minimum air temperature, water temperature and wind speed and direction are kept at the lock and dam. All daily data received by Water Control from the dam site is complied and archived using Hydraulic Engineering Center's Data Storage System (HEC-DSS) and is accessible from the Water Control web site at *www.mvp-wc.usace.army.mil*. By using the lock and dam data stored in DSS files, electronic logsheets were generated dating back to January 1988. The US Geological Survey (USGS) maintains a record of discharges for the Mississippi River at Muscoda and Clayton, the Wisconsin River at Muscoda, and the Kickapoo River at Steuben. The data are archived in the USGS WATSTORE data base in Reston, Virginia and are available from the annual publications of the USGS Water-Data Reports, Water Resources Data, Minnesota and Iowa. The daily record of max-min temperature, precipitation, weather characteristics, river stages, and general remarks are recorded on National Weather Service (NWS) Form B-91. This form is mailed at the end of each month to the NWS in La Crosse, Wisconsin.

5-05. Communication Network. The communication network consists of computer terminal, T1 line, telephone, pager, facsimile, FM radio, voice modem, satellite, and the US Postal Service. Computer communication is done via e-mail, and "Secure CRT" which allows remote access to the Water Control network. When the computer is down, the transfer of data is by facsimile, telephone, or FM radio. During non-duty hours on weekends and holidays, dam personnel can contact the river regulator by calling the pager number (612-660-8053). The gage sites on the Mississippi River at Clayton and McGregor, as well as the gages on the Wisconsin River at Muscoda and the Kickapoo River at Steuben, send hourly stage/elevation data via satellite to Water Control. This information is made available to the general public via the Water Control web site at *www.mvp-wc.usace.army.mil*. McGregor, Clayton, Muscoda, and Steuben gages have voice modems and can be contacted by telephone for immediate stage information. A T1 line ensures communication between Water Control and the Mississippi River Valley Division Office (MVD) in Vicksburg, Mississippi. Bulk items like Stevens PAV-C strip charts are delivered to Water Control through the postal service.

5-06. Communication with Project.

a. Regulating Office with Project Office. Dam site personnel input and transmit their data, via computer, to Water Control every day by 0630-hours. Water Control issues orders to Lock and Dam No. 10 every morning at approximately 0800-hours during the navigation season and around 0730-hours during the non-navigation season. Orders are typically delivered via e-mail with the telephone serving as backup. Should the dam site have computer problems, such that the transfer of data is not possible, a facsimile is to be sent to Water Control (651-290-5841). The Water Control river manager then enters the information into the Regulation Program and Information Management (IM) is notified of the computer problem. Communication with the project after orders are delivered is typically by telephone.

b. Between Project Office and Others. The general public has access to river level and discharge data by calling Water Control's "Corps of Engineers River Information Service" at 651-290-5861. This service provides a recording of daily stages/elevations and discharges along the Mississippi River. In addition, the Water Control web site at *www.mvp-wc.usace.army.mil* also provides river information to the general public. From here the public can access current water surface elevations for the Mississippi River as well as the daily log sheets for the locks and dams. Notifications of severe weather or impending unusual conditions are handled through local law enforcement, civil defense authorities, and the National Weather Service.

5-07. Project Reporting Instructions. The project staff is to report all hydrologic and climatic conditions to Water Control every morning by 0630-hours. The lock operator may make gate changes required to remain within the pool band issued by Water Control provided it is less than ten percent of the total river flow. All gate settings are to be logged in on “Secure CRT” every four hours. If the pool goes out of the band after 0400-hours, no gate changes are to be made by project staff until Water Control issues its morning orders. Gate changes to aid work efforts (e.g. painting) are to be coordinated with Water Control. Problems with machinery that operate the gates are to be reported to Water Control Section and Construction-Operations Division.

5-08. Warnings. In the event the lock operator makes a gate change to remain within the pool band issued by Water Control, Lock No. 10 personnel should notify Lock No. 11 of the cut or opening that was made. In the event of a gate failure, communications must be established as quickly as possible with the Water Control Section and the Construction-Operations Division. The installation of any bulkheads must be coordinated with Water Control.

VI – HYDROLOGIC FORECASTS

6-01. General. During periods of low flow, the gates at the dam are regulated to pass inflow under pooled conditions, while during high flow they are raised free of the water surface and except for a slight swellhead due to the effect of the piers, the dam offers little obstruction to the flow. The storage capacity created by the dam is relatively small as compared with the volume of flow and inasmuch as the dam is out of operation at high discharges, the use of the dam to control floods is not possible. The lock goes out of operation at elevation 621.0 feet (1912 adjustment) at which time water is at the top of the upstream miter gates. The timing and elevation of the crest is important for planning sand bagging operations and forecasting when the lock will go out of operation. In addition, the timing on the receding limb of the hydrograph aids in determining when the lock will go back into service. In 1997, the St. Paul District developed an unsteady-flow model of the Mississippi River.

a. Role of the Corps. The St. Paul District previously relied solely on the National Weather Service (NWS) for Mississippi River forecasts. Lock and Dam No. 10 is fortunate in that the forecast sites for Pool No. 10 are McGregor, Iowa, and Guttenberg, Iowa. These sites are part of the Advanced Hydrologic Prediction Service (AHPS), which forecasts five-days out during the flood season. The District saw a need for a model to forecast 30-days out, thereby giving the Corps time to react to the forecasted crest and to plan for the receding limb of the hydrograph (i.e. when the lock will go back into operation). In 1997, the District developed the Mississippi Basin Model System (MBMS). It utilizes the unsteady flow program UNET. The river regulator in the Water Control Section runs the MBMS model every morning. For the flood events of 1997 and 2001, the model provided excellent predictions of when the crest would occur and when the lock would be placed back into operation. This was of great use to planning sand bagging efforts, work scheduling, and keeping the towing industry abreast of the situation.

b. Roles of Other Agencies. The National Weather Service (NWS) electronically provides the District forecasted stage hydrographs of the major tributaries to the Mississippi River by 0830-hours daily. Water Control Section inputs these hydrographs into the Mississippi Basin River System (MBMS) model and makes a run. The MBMS model converts the stage hydrographs to flow hydrographs, routes the flow, then converts the discharge hydrographs at the locks and dams and points of interest (e.g. McGregor) back into stage hydrographs. The results are then electronically transferred to the NWS River Forecast Center in Chanhassen, Minnesota by 0930-hours. The NWS uses the UNET results and the results from their Mississippi River forecast model to provide stage forecasts at various points along the Mississippi River.

6-02. Flood Condition Forecasts. Since 1997, St. Paul District has been using the Mississippi Basin Modeling System (MBMS) to forecast flood conditions on the Mississippi River from Upper St. Anthony Falls to Lock and Dam No. 10. The system utilizes UNET, which is an unsteady flow computer program. UNET was modified to simulate navigation dams according to operating rules. While the program allows the operating rules to vary according to the season, it does not account for gate operation. Therefore, model results are limited while the dam is in a regulated condition. Flow and stage data are required to provide the boundary conditions that drive the model. Observed stages are updated daily. The model is dependent upon forecasted tributary inflow. The National Weather Service (NWS) electronically mails the 14-day forecasted stage hydrographs for the major tributaries to Water Control by 0830-hours daily. The hydrographs typically include the 24-hour quantitative precipitation forecast (QPF). Water Control extrapolates the tributary stage hydrographs to 30 days. Forecasts beyond five-days are very approximate due to unknowns such as additional rainfall. Therefore, only the five-day forecast for the locks and dams is made available to the public via the Water Control web site; *www.mvp-wc.usace.army.mil*. A seven-day forecast for the locks and dams as well as other points of interest (e.g. McGregor) is available to Corps personnel through the Intranet.

Modeling efforts as part of the Corps of Engineers Water Management System (CWMS) began in 2001. CWMS will contain hydrologic and hydraulic models of the District's reservoirs and the locks and dams. When the Mississippi River portion of CWMS becomes operational, the functionality of the MBMS model will be replaced. Rather than using UNET, CWMS will use a HEC-RAS unsteady flow model. The sharing of data with the NWS will remain unchanged.

6-03. Long-Range Forecasts. The Mississippi Basin Modeling System (MBMS) is used for making long-range forecasts. It is run everyday at about 0930-hours. The model forecasts elevation and discharge for the locks and dams and control points 30-days out. However, as previously noted, the five-day tributary inflow provided by the National Weather Service only includes the 24-hour quantitative precipitation forecast (QPF). Therefore, judgment is required when looking at long-range forecasts.

6-04. Drought Forecast. The lock and dam system operates as "run of the river". That is what ever flow enters the pool is passed on. During low flow, the project pool elevation is maintained provided there is sufficient inflow to meet withdrawal needs and pool evaporation. There is no drought forecasting model other than the Mississippi Basin Modeling System previously discussed.

VII - WATER CONTROL PLAN

7-01. General Objectives. The general objective of the water control plan is to maintain a minimum depth of nine feet along the navigation channel of Pool No. 10, without inducing higher stages during flood events. Project pool elevation for Lock and Dam No. 10 is 611.0 ± 0.2 feet (1912 adjustment). Unlike most other St. Paul District Locks and Dams, the primary control point is at Lock and Dam No. 10 rather than at the intersection of the ordinary high water line and the project pool elevation. Maintaining project pool elevation at the dam during periods of low flows ensures a minimum channel depth of nine feet with periodic dredging.

The dam has minor localized impacts during flood events. The required spillway area at the dam was designed such that when all the gates are out of the water, the swellhead produced by the piers is less than one foot. Long before flood stage is reached, all the gates are raised above the water surface so that natural open river conditions exist during the flood period.

7-02. Constraints.

a. Pool Levels. For low discharges, the pool is maintained at elevation 611.0 ± 0.2 feet (1912 adjustment) at the primary control point at the lock and dam. This is “project pool” or “normal pool” for Lock and Dam No. 10 and was mandated by the 79th Congress (1st Session, House Document No. 137, 9 December 1931). During low flows, the pool is constrained to this level. At higher discharges, when a drawdown at the dam is permissible, the water level at the dam is constrained such that it may not be lower than elevation 610.0 ± 0.2 feet (i.e. 1.0 foot drawdown).

b. Maximum Outflow Velocity. Downstream scour protection limits outflow velocities from the roller and tainter gates. The design plan set maximum outflow velocities at 4.5 feet per second for standard operating procedures with an allowance to go to 6.0 feet per second for an emergency situation. In 1983, additional riprap was placed upstream and downstream of the dam. Since this time, routine maximum gate openings have been computed based on a maximum outflow velocity of 6.0 feet per second. The design velocity of 6.0 feet per second may be exceeded for short periods of time (15 to 20 minutes) during emergency operations (e.g., barge incident, passing of debris).

c. Open River Conditions. The dam is "out of control" when the gates are raised clear of the water surface and "open river conditions" exist. This typically happens when the differential head is less than one foot and the discharge is around 75,000 cfs. When gates are put back in the water, the total gate openings are 56 feet on roller gates and 112 feet on tainter gates.

d. Closure of the Lock to Navigation. Prior to 1997, the lock would close to navigation when high water dictated the removal of the miter gate motors. This occurred when the upper pool reached elevation 619.0 feet (1912 adjustment). As part of the major rehabilitation work in 1997, the motors were raised; therefore, the lock can now technically remain open to navigation provided water is not spilling over the upper miter gates of the main lock. This occurs at elevation 621.0 feet. However, it is not unusual for the Coast Guard to close the river to navigation before this elevation is reached.

The lock is also closed when ice is too thick to permit tow traffic. As winter approaches, the lock remains open as long as towboats and barges can travel. Water temperatures are monitored to predict lock closure. Ice can form overnight and can impact the entire pool. In early March the ice becomes thin enough for some tow traffic and the lock is opened. The following table shows some of the recent history of opening and closing dates for Lock and Dam No. 10.

Table 7-1 Spring Opening and Fall Closing Dates (1970 – 2002)					
Year	Opening Date	Closing Date	Year	Opening Date	Closing Date
1970	06-Mar	11-Dec	1987	05-Mar	04-Dec
1971	04-Mar	15-Dec	1988	12-Mar	10-Dec
1972	18-Mar	16-Dec	1989	13-Mar	27-Nov
1973	07-Mar	14-Dec	1990	07-Mar	30-Nov
1974	13-Mar	14-Dec	1991	13-Mar	27-Nov
1975	02-Mar	15-Dec	1992	05-Mar	08-Dec
1976	26-Feb	19-Dec	1993	09-Mar	01-Dec
1977	17-Mar	20-Dec	1994	14-Mar	08-Dec
1978	03-Apr	01-Dec	1995	11-Mar	01-Dec
1979	29-Mar	05-Dec	1996	17-Mar	29-Nov
1980	22-Mar	05-Dec	1997	10-Mar	05-Dec
1981	02-Mar	12-Dec	1998	03-Mar	18-Dec
1982	23-Mar	15-Dec	1999	06-Mar	15-Dec
1983	01-Mar	13-Dec	2000	02-Mar	07-Dec
1984	01-Mar	05-Dec	2001	01-Mar	08-Dec
1985	12-Mar	02-Dec	2002	13-Mar	30-Nov
1986	19-Mar	04-Dec	2003	21-Mar	11-Dec

e. Maximum Number of Gates Closed. At times it is necessary to close one or more gates for maintenance purposes. All gate closures shall be coordinated with the river regulation desk at the Water Control Section. The maximum number of gates allowed to be closed will be at the discretion of Water Control based on conditions as they exist. **Table 7-2** was prepared based on outlet velocities of 4.5 feet per second.

Table 7-2
Maximum Number of Gates Allowed to be Closed

Flow (cfs)	No. of Roller Gates Closed
Below 22,000	4
22,000 – 30,000	3
22,000 – 30,000	2
30,000 – 39,000	1
Above 39,000	0

Flow (cfs)	No. of Tainter Gates Closed
Below 26,000	8
26,000 – 29,000	7
29,000 – 33,000	6
33,000 – 37,000	5
37,000 – 41,000	4
41,000 – 46,000	3
46,000 – 50,000	2
50,000 – 55,000	1
Above 55,000	0

Note that **Table 7-2** assumes **either** roller gates **or** tainter gates are being closed. Any mixing of roller gate and tainter gate closures would require additional evaluation by Water Control.

7-03. Overall Plan for Water Control.

a. General Plan. The navigation channel of Pool No. 10 is 300 feet wide along the straight reaches of the river and varies from 300 feet to 550 feet in the bends. The primary purpose of Lock and Dam No. 10 is to maintain a minimum depth of nine feet throughout the navigation channel without inducing higher stages during flood events. To meet depth requirements in the upper pool requires the pool elevation at the dam to be at elevation 611.0 feet (1912 adjustment) during flows of less than 42,000 cfs. Therefore, "project pool" elevation for Lock and Dam No. 10 is 611.0 ± 0.2 feet. As flow increases, project pool elevation is maintained at the dam by opening the gates. The increase in flow imparts a slope to the water surface profile throughout the pool. When the stage at Clayton, Iowa reaches elevation 611.8 feet (stage: 9.2 feet), regulation is shifted to secondary control. Clayton acts as the "secondary control point" where elevation 611.8 ± 0.2 feet is maintained. As flow continues to increase, gates are opened at the dam to maintain the secondary control elevation. This results in a drawdown in the water surface elevation at the dam. Maximum allowable drawdown is one foot below project pool elevation or 610.0 feet. When the discharge reaches around 52,000 cfs, maximum drawdown at the dam has been achieved. At this point the dam becomes the control point again and the gates are raised to maintain the "tertiary" control elevation of 610.0 ± 0.2 feet. At around 73,000 cfs, the differential head is reduced to less than one foot and it becomes difficult to maintain tertiary control. By the time discharge reaches 78,000 cfs, the gates have been raised above the water surface and the dam is said to be "out of control" or in "open river conditions". **Table 7-3** summarizes pool operation for Lock and Dam No. 10. As discharge decreases from open river conditions, the gates are returned to the water when the pool at the dam reaches elevation 610.0 feet and tertiary control is initiated. When the stage at Clayton returns to elevation 611.8 feet, secondary control is put into effect until the pool at the dam rises to elevation 611.0 feet at which time primary control is returned. The operating curves for the pool and tailwater are shown on **Plate 7-1**. The curves were updated based on the expanded historical record starting with the reduced drawdown in 1971.

Table 7-3
Control Conditions at Lock and Dam No. 10

Control Conditions	Approximate Discharge	Clayton Gage Elevation	Lock and Dam 10 Pool Elevation
Primary	< 42,000 cfs	≤ 611.8 ft	611.0 ft
Secondary	42,000 to 52,000 cfs	611.8 ft	< 611.0 ft > 610.0 ft
Tertiary	52,000 to 78,000 cfs	> 611.8 ft	610.0 ft
Open-River	> 78,000 cfs	> 611.8 ft	> 610.0 ft

b. Computed Discharge. Discharges are computed "on the fly" as pool elevation, tailwater elevation, and gate settings are received in Water Control. The program contains head vs. discharge curves, based on per foot gate opening, for roller and tainter gates. When gates 1 and 12 are submerged, **Table 7-4** can be used to determine discharge for these gates. The table is incorporated into the program. The gates are typically submerged to the maximum depth of three feet below normal pool.

Table 7-4
Discharge Over Tainter Gates Submerged to Elevation 608.0 ft (1912)

Pool Elevation	609.0 ft	610.00 ft	610.5 ft	611.0 ft	611.5 ft	612.0 ft
Discharge per Gate	240 cfs	530 cfs	670 cfs	830 cfs	1040 cfs	1260 cfs

At high discharges when the gates are out of the water, discharges are computed based on the tailwater-rating curve. To prevent a discontinuity from computed outflows to the tailwater rating curve, outflows are transitioned within the program to the tailwater rating.

Discharge ratings for the gates were originally developed based on laboratory tests with a hydraulic model. A Gate Regulation Schedule was developed based on gate discharge, maximum outflow velocity of 4.5 feet per second, and an effort to equally distribute flow across the dam. In 1973, the US Geological Survey measured outflows in the prototype. This resulted in a new relationship in the per foot discharge for the roller and tainter gates. The analysis also showed a slight change in the tailwater rating. These changes were presented in a new Gate Regulation Schedule (revised November 1973). Included with the change in per foot discharge, was a reevaluation of the flow distribution across the dam. Flow was now to be distributed based on balancing outflow velocities.

The Gate Regulation Schedule underwent another change in 1983 when additional riprap placed upstream and downstream allowed higher velocities and hence larger maximum allowable gate settings.

In 1998, the St. Paul District contracted with Barr Engineering Company to verify the measurements taken in 1973. The discharge measurements were made using an Acoustic Doppler Current Profiler (ADCP). Flows were measured at both the tainter gates and the roller gates. Flow equations were developed for different head conditions and curves were plotted. Barr's results are shown on **Plate 7-3** in comparison with the 1973 curves. When Barr made the gate discharge measurements, they also took a full-river discharge measurement downstream of the dam. **Table 7-5** shows a comparison of the full-river discharge measurements to the computed values using the 1973 curves and the 1998 curves. The 1973 values are within 3 to 9 percent of the measured full-river discharges whereas the computed values based on the 1998 measurements differ from the measured full-river discharges by 7 to 11 percent.

Table 7-5
Comparison of Full-River Discharge Measurements to Computed Flows

Date of Measure-Ment	Head Difference (feet)	Tainter Gate Opening (feet)	Roller Gate Opening (feet)	Measured Discharge (cfs)	Computed (1973) Discharge (cfs)	Percent Difference	Computed (1998) Discharge (cfs)	Percent Difference
5-May-98	2.57	64	32	60,970	55,490	- 9 %	65,490	7 %
6-Jun-98	5.07	24	22	39,290	39,210	0 %	43,480	11 %
11-Oct-98	6.60	21	7	25,480	24,760	- 3 %	27,510	8 %

Hence the current Gate Regulation Schedule was not revised to incorporate this new data; however, it was updated to include minor changes in maximum allowable gate openings due to changes to the operating curves (**Plate 7-1**). **Table 7-6** shows the current Gate Regulation Schedule.

As in 1973, the distribution of flow was based on equalizing the outflow velocities. For example, consider a flow of 40,000 cfs and a respective head across the dam of 5.15 feet with a tailwater elevation of 605.85 feet (1912 adjustment). The discharge per foot opening for roller and tainter gates are 1,045 cfs and 701 cfs, respectively. By setting the roller gates at a total opening of 20.5 feet (20.5 x 1,045 = 21,400 cfs) and the tainter gates at 26.5 feet (26.5 x 701 = 18,600 cfs) gives a total discharge of 40,000 cfs. Outflow velocities are calculated based on $Q=VA$, where Q is the discharge in cfs, V is the flow velocity in fps, and A is the flow area in sq ft. Q is the discharge through one gate. Area is the gate width, plus one pier width, times the depth of flow over the end sill. Roller gates are 80-feet long with a pier width of 15 feet. Tainter gates are 40-feet long with a pier width of 8 feet. The respective average end sill elevations for roller and tainter gates are 589.2 feet and 591.3 feet (**Section 2.03. Physical Components. b. Moveable Dam**). Therefore, the flow velocities are:

Roller Gate
Q = *VA*
(20.5 ft/4 roller gates) 1,045 cfs = V (80 ft + 15 ft) (605.85 ft – 589.2 ft)
V = 2.39 ft/sec

Tainter Gate
Q = *VA*
(26.5 ft/8 tainter gates) 701 cfs = V (40 ft + 8 ft) (605.85 ft – 591.3 ft)
V = 2.44 ft/sec

To complete the update of the Gate Regulation Schedule to reflect the change in per foot discharge, also requires a change in the maximum allowable gate openings. Maximum allowable gate openings are based on flow velocity at the end sill downstream of the gates. Again, let's consider a discharge of 40,000 cfs and a differential head of 5.15 feet with a tailwater elevation of 605.85 feet. Based on *Q* = *VA*, where *Q* is the discharge per foot, times the maximum allowable gate opening, *V* is the maximum allowable flow velocity of 6.0 feet per second, and *A* is the flow area over the end sill for one gate, the following maximum allowable gate openings were determined.

Roller Gate
Q = *VA*
1,045 cfs (max gate opening in ft) = 6.0 fps (80 ft + 15 ft) (605.85 ft – 589.2 ft)
Max Gate Opening = 9.1 ft

Tainter Gate
Q = *VA*
701 cfs (max gate opening in ft) = 6.0 fps (40 ft + 8 ft) (605.85 ft – 591.3 ft)
Max Gate Opening = 6.0 ft

Table 7-6 shows the new Gate Regulation Schedule.

Table 7-6
Gate Regulation Schedule
4 Roller Gates and 8 Tainter Gates

Total Discharge cfs	Total Gate Opening in Feet		Elevation in Feet 1912 Adjustment		Head In Feet	Discharge (cfs) per Foot of Opening		Discharge (cfs)		Max Allowable Opening of a Gate	
	Rollers	Tainters	Pool	TW		Rollers	Tainters	Rollers	Tainters	Rollers	Tainters
10,000	4.5	5.0	611.00	602.85	8.15	1310	830	5,895	4,150	5.9	4.0
11,000	5.0	5.5	611.00	602.95	8.05	1302	828	6,510	4,554	6.0	4.1
12,000	5.5	6.0	611.00	603.05	7.95	1295	826	7,123	4,956	6.1	4.1
13,000	5.5	7.0	611.00	603.15	7.85	1287	823	7,079	5,761	6.2	4.1
14,000	6.0	7.5	611.00	603.25	7.75	1279	821	7,674	6,158	6.3	4.2
15,000	6.5	8.0	611.00	603.35	7.65	1272	819	8,268	6,552	6.3	4.2
16,000	7.0	8.5	611.00	603.45	7.55	1264	816	8,848	6,936	6.4	4.3
17,000	7.5	9.5	611.00	603.55	7.45	1256	814	9,420	7,733	6.5	4.3
18,000	7.5	10.5	611.00	603.65	7.35	1248	811	9,360	8,516	6.6	4.4
19,000	8.5	10.5	611.00	603.75	7.25	1240	808	10,540	8,484	6.7	4.4
20,000	9.0	11.0	611.00	603.85	7.15	1232	805	11,088	8,855	6.8	4.5
21,000	9.0	12.5	611.00	603.95	7.05	1224	802	11,016	10,025	6.9	4.5
22,000	9.5	13.0	611.00	604.05	6.95	1216	798	11,552	10,374	7.0	4.6
23,000	10.5	13.0	611.00	604.15	6.85	1206	794	12,663	10,322	7.1	4.7
24,000	11.0	13.5	611.00	604.25	6.75	1197	790	13,167	10,665	7.2	4.7
25,000	11.5	14.5	611.00	604.35	6.65	1189	786	13,674	11,397	7.3	4.8
26,000	12.0	15.0	611.00	604.45	6.55	1180	782	14,160	11,730	7.4	4.8
27,000	12.5	16.0	611.00	604.55	6.45	1171	778	14,638	12,448	7.5	4.9
28,000	13.0	16.5	611.00	604.65	6.35	1162	774	15,106	12,771	7.6	5.0
29,000	13.5	17.5	611.00	604.75	6.25	1153	770	15,566	13,475	7.7	5.0
30,000	14.0	18.0	611.00	604.85	6.15	1144	766	16,016	13,788	7.8	5.1
31,000	14.5	19.0	611.00	604.95	6.05	1135	762	16,458	14,478	7.9	5.2
32,000	15.0	20.0	611.00	605.05	5.95	1125	757	16,875	15,140	8.0	5.2

Table 7-6 – Continued Gate Regulation Schedule 4 Roller Gates and 8 Tainter Gates												
Total Discharge cfs	Total Gate Opening in Feet		Elevation in Feet 1912 Adjustment		Head In Feet	Discharge (cfs) per Foot of Opening		Discharge (cfs)		Max Allowable Opening of a Gate	
	Rollers	Tainters	Pool	TW		Rollers	Tainters	Rollers	Tainters	Rollers	Tainters
33,000	16.0	20.0	611.00	605.15	5.85	1115	750	17,840	15,000	8.2	5.3
34,000	16.5	21.0	611.00	605.25	5.75	1105	743	18,233	15,603	8.3	5.4
35,000	17.0	22.5	611.00	605.35	5.65	1095	736	18,615	16,560	8.4	5.5
36,000	17.5	23.5	611.00	605.45	5.55	1085	729	18,988	17,132	8.5	5.6
37,000	18.5	23.5	611.00	605.55	5.45	1075	722	19,888	16,967	8.7	5.7
38,000	19.5	24.0	611.00	605.65	5.35	1065	715	20,768	17,160	8.8	5.8
39,000	20.0	25.5	611.00	605.75	5.25	1055	708	21,100	18,054	8.9	5.9
40,000	20.5	26.5	611.00	605.85	5.15	1045	701	21,423	18,577	9.1	6.0
41,000	21.0	28.0	611.00	605.96	5.04	1034	693	21,714	19,404	9.2	6.1
42,000	22.0	28.5	611.00	606.06	4.94	1024	686	22,528	19,551	9.4	6.2
43,000	23.0	29.0	611.00	606.17	4.84	1012	679	23,276	19,691	9.6	6.3
44,000	24.0	30.5	610.95	606.27	4.68	994	664	23,856	20,252	9.8	6.5
45,000	25.0	31.5	610.88	606.38	4.51	974	652	24,350	20,538	10.0	6.6
46,000	26.0	33.0	610.80	606.48	4.32	952	639	24,752	21,087	10.3	6.8
47,000	27.0	35.0	610.70	606.59	4.12	929	628	25,083	21,980	10.5	6.9
48,000	28.5	36.5	610.60	606.69	3.91	905	612	25,793	22,338	10.8	7.1
49,000	30.5	37.5	610.48	606.80	3.69	879	592	26,810	22,200	11.0	7.2
50,000	32.0	39.5	610.35	606.90	3.45	852	571	27,264	22,555	11.3	7.5
51,000	34.0	42.0	610.20	607.00	3.20	823	548	27,982	23,016	11.6	7.7
52,000	36.0	45.5	610.00	607.10	2.90	788	519	28,368	23,615	12.0	8.0
53,000	37.5	47.0	610.00	607.20	2.80	776	509	29,100	23,923	12.3	8.3
54,000	38.5	49.5	610.00	607.30	2.70	764	499	29,414	24,701	12.7	8.6
55,000	39.5	52.0	610.00	607.40	2.60	752	488	29,704	25,376	13.2	8.9

Table 7-6 – Continued
Gate Regulation Schedule
4 Roller Gates and 8 Tainter Gates

Total Discharge cfs	Total Gate Opening in Feet Rollers	Tainters	Elevation in Feet 1912 Adjustment Pool	TW	Head In Feet	Discharge (cfs) per Foot of Opening Rollers	Tainters	Discharge (cfs) Rollers	Tainters	Max Allowable Opening of a Gate Rollers	Tainters
56,000	41.0	53.5	610.00	607.50	2.50	740	478	30,340	25,573	13.7	9.3
57,000	42.0	56.5	610.00	607.60	2.40	728	467	30,576	26,386	14.2	9.8
58,000	43.5	59.0	610.00	607.70	2.30	716	456	31,146	26,904	14.7	10.4
59,000	45.0	61.5	610.00	607.80	2.20	704	446	31,680	27,429	15.1	10.7
60,000	46.0	64.5	610.00	607.90	2.10	692	436	31,832	28,122	15.4	11.0
61,000	48.0	66.5	610.00	607.99	2.01	681	426	32,688	28,329	15.7	11.3
62,000	49.5	69.0	610.00	608.08	1.92	671	416	33,215	28,704	16.0	11.6
63,000	52.0	71.0	610.00	608.17	1.83	661	405	34,372	28,755	16.4	12.0
64,000	53.0	75.0	610.00	608.26	1.74	651	395	34,503	29,625	16.7	12.4
65,000	54.0	78.5	610.00	608.35	1.65	642	385	34,668	30,223	17.0	12.8
66,000	56.0	82.0	610.00	608.44	1.56	632	374	35,392	30,668	17.4	13.2
67,000	57.5	86.0	610.00	608.53	1.47	622	364	35,765	31,304	17.7	13.6
68,000	60.0	88.5	610.00	608.62	1.38	612	353	36,720	31,241	18.1	14.1
69,000	62.0	92.5	610.00	608.71	1.29	602	343	37,324	31,728	18.5	14.6
70,000	63.5	97.5	610.00	608.80	1.20	592	333	37,592	32,468	18.9	15.1
71,000	66.0	101.0	610.00	608.89	1.11	582	323	38,412	32,623	19.3	15.7
72,000	67.0	106.0	610.00	608.95	1.05	576	316	38,592	33,496	19.5	16.1
73,000	69.0	112.0	610.00	609.04	0.96	565	305	38,985	34,160	20.0	16.8
74,000	71.5	117.0	610.00	609.13	0.87	554	294	39,611	34,398	-	17.5
75,000	74.5	123.0	610.00	609.23	0.77	542	282	40,379	34,686	-	18.3
76,000	77.0	130.0	610.00	609.32	0.68	530	270	40,810	35,100	-	19.2
77,000	78.5	140.0	610.00	609.41	0.59	519	259	40,742	36,260	-	-
78,000	Out of Control – Gates clear of water. Put gates back in at 56 ft Roller Gates and 112 ft Tainter Gates.										

c. Regulation Procedure. Each morning at 0635-hours, the Water Control manager prints the Regulation Sheets containing all the input from the lock and dam sites. Regulation for Lock and Dam No. 10 begins at Lock and Dam No. 4. Gate changes at Lock and Dam No. 4 directly influence action needed at Dam No. 5, which in turn directly influences Dam No. 5A, and so on down to Lock and Dam No. 10. After regulating Lock for Dam 9, inflow to Pool No. 10 is determined. Inflow consists of outflow from Lock and Dam No. 9, inflow from the Wisconsin River, and any miscellaneous inflow. Outflow from Lock and Dam No. 9 is computed as part of the daily regulation. River stages/elevations for the gages located at Clayton and McGregor on the Mississippi River and Muscoda and Steuben on the Wisconsin and Kickapoo Rivers are directly input to River Program from their respective DCP's. The River Program computes discharge for Muscoda and Steuben from rating tables and both stage and discharge are automatically input to the Regulation Sheet. Miscellaneous inflow will vary seasonally but for simplicity it is assumed to be a constant 200 cfs. This may be modified if precipitation has occurred in the last 24-hours. As a general rule, for each inch of rainfall that has fallen in past 24-hours, an additional 700 cfs is added to the miscellaneous inflow. Inflow is totaled and the 24-hour change is noted. Also noted are the change in outflow and any gate changes made in the past 24-hours. Next the rate of fall or rise of the pool is calculated. This is done at the dam, Clayton, and McGregor. Note the changes. Allow for wind at the dam. That is, adjust the pool elevation up or down 0.1 foot per 10 mph of wind (see **Section 4-04**). Determine if the pool is in primary, secondary, or tertiary control. Estimate the needed change in discharge to maintain the proper pool band. To aid in this assessment, it has been determined that a change in outflow of 1000 cfs over a 24-hr period of time will result in about a one tenth of a foot change in the overall pool elevation. This value was computed based on the effective project pool area of 17,070 acres.

Once the needed change in discharge is determined, the Gate Regulation Schedule is used to distribute flow and hence set gate changes. The "daily orders" are emailed to the lock site at approximately 0800-hours each day. The orders are typically one of four types; (1) no change, (2) no change at present, (3) open a given amount, or (4) cut a given amount. A "no change at present" order is followed by an "if statement". For example, "if the pool falls to elevation 610.8 feet, cut 1 foot on roller gates". All "open" and "cut" orders include the anticipated gate change impact on flow. All four types of orders are followed by a "pool band" to be maintained at the dam. For example, "hold 611.0 ± 0.2 feet". As a final note, the orders may also include "allow for wind on the high side" or "allow for wind on the low side", if appropriate. Sometimes it is necessary to check back with the lock site in the afternoon. If this were the case, the site would be informed, via the morning's orders, that Water Control will be contacting them at a given time (typically 1400-hours). At that time, site personnel would provide present and noon pool and tailwater elevations, and present weather conditions. Water Control would then provide any gate change verbally over the telephone or via e-mail.

The following is a sample of the regulation of Lock and Dam No. 10. The portion printed in black represents the daily regulation sheet while that printed in blue represents regulation notes.

Regulation of Lock and Dam No. 10 for 26 September 2001

```
      Orders to LD 9:  No change at present. If pool climbs to 619.75
                       open 1.5 ft RG and Call LD10.
      Note: Roller Gates at LD 9 where opened 2 ft between 8 am and
            noon.
                                            4-RG    8-TG
gates in/out:   56/112 @ 73,000             Total   Total        42K-52K <611.8>
                                            Roller  Tainter              CP-10
LOCK 10         Pool    Tail     Flow       Gate    Gate       McGregor  Clayton
          ------------------------------------------                TM10      TM10
25SEP01  0800   611.22  604.96   33000      17.0     16.0       612.76    611.85
         1200   611.19  605.07   34900      19.0     16.0      ←—— Open 2 ft
         1600   611.23  605.08   35100      19.0     16.0
         2000   611.21  605.10   35000      19.0     16.0
         2400   611.22  605.12   34900      19.0     16.0
26SEP01  0400   611.25  605.14   35000      19.0     16.0
         0630   611.26  605.16   35100      19.0     16.0       612.91    611.94
                up 0.04          up 2100                        up 0.15   up 0.09
                                                                  Muscoda   Steuben
phone    HEAD      6.1                                             TM9       TM9
##035    Q/foot    1158/764                          Stage:       1.94      8.18
         temp.     41
         precip.   0.00                              Flow:        7072      713
         wind (dir&speed)      @    0

           INFLOW:
           L/D 9 -      24200                Orders:
           Wisconsin - 7800                  Open 2.0 ft on TG
           1000 CFS -                        increase 1400 to 36500
           Misc.     -  _ 200                Hold 611.00 ± 0.2 ft
                        32200 up 1,100

Q less than 42,000  |  42K-52K transition  |  Q between 52,000–73,000
  hold pool 611.0   |    Clayton > 611.8   |    hold pool 610.0
```

The following steps walk through the regulation procedure for this particular day. This is intended only as an example.

Step 1. Determine inflow to Pool 10.
- LD 9 Orders: No change at present, maintain 24,200 cfs.
- Wisconsin River is at 7,800 cfs.
- Miscellaneous inflow is 200 cfs.
- Rainfall was 0.0 inches.
- Total Inflow = 32,200 cfs (up 1,100 cfs from yesterday).

Step 2. Note change in outflow.
- Up 2,100 cfs due to gate change.

Step 3. Note change in pool elevation.
- Pool is up 0.04 ft at dam; 0.10 ft at Clayton; 0.15 ft at McGregor.
- Wind is 0 mph. Pool is up on average 0.10 ft.

Step 4. Primary, Secondary, or Tertiary Control?
- Flow is less than 42,000 cfs; therefore, Primary Control.
- Primary Control is 611.00 ± 0.2 ft at the dam.

Step 5. Estimate needed change in discharge.

Note “Q/foot” estimates discharge/foot gate opening roller/tainter
Pool will increase/decrease 0.1 foot per 1,000 cfs in 24 hrs.
The pool is up on average about 0.09 feet (900 cfs).
The pool is 0.06 feet out of the band on the high side (600 cfs).
Needed Change in Outflow: 900 + 600 = 1,500 cfs

Step 6. Set gate change.

The Gate Reg Schedule shows ideal gate settings for 37,000 cfs to be 18.5 ft on RG and 23.5 ft on TG.
We are presently 19.0 on RG and 16.0 on TG.
Therefore, the entire gate opening will be on the Tainter Gates.
“Q/foot” indicates 1-foot change on TG’s is 764 cfs.
(This does not account for a rise in TW and hence it is high.)
A two-foot opening on TG’s would increase outflow ~1,400 cfs.
“Open 2.0 ft on TG. Increases flow 1,400 to 36,500.”

Step 7. Set the pool band.

Present pool is 611.26 ft. The opening should cause a drop.
“Hold elevation 611.00 ± 0.2 feet.”

d. Winter Regulation. Each year in early winter, the two submersible tainter gates (gates no. 1 and 12) are set at minus three feet to help pass debris and ice. The remainder of the tainter gates are set somewhere from 1.0 to 1.5 feet and are allowed to freeze in place. The roller gates have electric drum and side seal heaters that help keep them from freezing in place. Therefore, change in flow is done by adjusting the roller gates, which are in the normal position.

To determine what the tainter gate settings should be before freeze up, requires an estimate of the anticipated minimum base flow for the winter months. Water Control makes an estimate based on the average flow from 1 October through 15 November and the minimum winter flow rate curve. The curve was developed using historic discharge information for the gage site at McGregor, Iowa. “Average October Flow” and “Average November Flow” were plotted against the “Minimum Winter Flow”. Curves were drawn through the lowest data points. A composite curve was then developed. By entering the average flow for the period 1 October through 15 November, the anticipated minimum base flow can be selected from the curve. The recommended tainter gate settings are sent to the Lockmaster for evaluation. The Lockmaster assesses the Water Control recommendations and makes the final decision on tainter gate settings before freeze up.

Throughout the winter, the tainter valves in the lock walls are kept open one or two feet so that the lock chamber will remain ice free. This flow is about 1/10th of the discharge under a normal roller gate with the same head and the same gate opening. Additionally, the flow through the lock chamber reduces deposition of sediment.

During the winter, on the weekends and holidays, the shifts are limited to one person at the dam site. Two people are required to make a gate change. There is a one half hour overlap in the morning between the 0730 and 0800-hours. Therefore, Water Control makes an effort to get orders out by 0730-hours. Due to the limited staff at the site and the difficulty in moving the roller gates and/or tainter gates, the tolerance for stage deviation is increased to plus or minus three tenths of a foot. Lock and Dam No. 10 is typically maintained at elevation 611.0 ± 0.3 feet. A high pool level during the winter reduces oxygen depletion in the backwater areas, which benefits fish habitat. Therefore, Water Control operates on the high side of the band during winter months.

7-04. Standing Instructions to Lock and Dam No. 10 Staff.

a. Data Collection. Lock and dam personnel are to collect and report various hydraulic data to Water Control via “Secure CRT”. The data entry interval varies from once a day to every four hours. Four-hour data begins at 0400-hours and includes pool elevation, tailwater elevation, gate settings, and tainter valve settings (winter only). Eight-hour data begins at 0800-hours and includes air temperature and wind speed and direction. Daily data includes max-min air temperature (2400-hours), water temperature (0800-hours), precipitation (0800-hours), and the water surface elevations at Clayton and

McGregor gage sites (0800-hours). All 0800-hour data are actually collected at 0600-hours. Max-min air temperature is actually taken at 1900-hours.

During the winter months site personnel are report percent of pool and tailwater ice coverage, pool and tailwater ice thickness, snow depth, and snow-water equivalent (all in inches) via “Secure CRT”. These data are collected once a week on Sundays. The snow-water content is to be determined by instructions contained in the National Weather Service Observing Handbook No. 2.

The Stevens PAV-C strip charts are to be mailed to Water Control every year.

b. Lock and Dam Operations. The Water Control regulator analyzes the field data and at around 0800-hours, the daily orders for gate movements are sent to the site via e-mail. On weekends and holidays during the winter operations, orders are sent by 0730-hours due to limited staffing at the dam site. Gate changes are then made as soon as possible. If Water Control has notified the site that they will contact them again later in the day, site personnel will have the noon and present pool and tailwater elevations as well as any other pertinent information (e.g. wind speed and direction) available at that time.

Normal duty hours for Water Control are 0630 to 1500-hours during the week, and 0630 to 0930-hours on weekends and holidays. During the course of non-duty hours site personnel may make gate changes as necessary to stay within the pool band prescribed. When a gate change is made, call Lock and Dam No. 11 and notify them. The site is limited to changes of up to ten percent of the 1600-hour discharge. If a gate change greater than this is necessary, site personnel should contact the river regulator at home. If the need for a gate change becomes necessary at 0400-hours, no gate change will be made. Water Control will provide the necessary gate change and band limit with the morning’s orders. The following is a list of Water Control personnel with river responsibilities. The first contact should be the person who issued the last orders. If that person is not available, contact should be made in the order listed in **Table 7-7**. The weekend pager number is 612-660-8053. Lock personnel contacting Water Control personnel during non-duty hours should have pool and tailwater readings, wind speed and direction, amount of precipitation since last report, latest discharge calculations, and all gate changes made since the morning gate change.

Table 7-7
Water Control Personnel Telephone Numbers

Name	Non-Duty Telephone	Office Telephone
Scott Bratten	651-436-6135	651-290-5624
Ted Pedersen	715-639-2625	651-290-5253
Dennis Holme	651-483-4003	651-290-5614
Farley Haase	715-235-1928	651-290-5633
Ferris Chamberlin	651-653-7981	651-290-5619
Robert Engelstad	651-459-6343	651-290-5610

If lock personnel have any questions regarding the Water Control order, they are to contact the river regulator via telephone (651-290-5624) and the question will be resolved. During computer outages, log sheets will be faxed to Water Control Section (651-290-5841) and orders will be given via telephone.

In the event of a gate failure or any occurrence that will require the installation of the bulkheads, communications must be established as quickly as possible with Water Control Section and Construction and Operations (Con-Ops) Division. Under full head conditions at the dam, the force is too great to allow the installation of the bulkheads. Therefore, the operating head must be reduced. Water Control will coordinate gate movements with site personnel in preparation for installation and removal of the bulkheads.

7-05. Flood Control. Lock and Dam No. 10 has no flood control benefits. It is operated strictly for navigation. While it may seem possible that the pools be drawdown over the winter months to provide storage for spring runoff, this plan has no merit for two reasons. First the Anti-Drawdown Law (Public Law 697) of June 1948 prevents the drawdown of the pools during the winter months. Secondly, the storage volume that would be made available in the pool is insignificant in comparison to the flood flow volume. The pool would be filled in a matter of hours and would have no impact on the peak flood stage.

7-06. Recreation. The major recreation features for Lock and Dam No. 10 are fishing, hunting and boating. Construction of the lock and dam inundated the numerous wing dams that were constructed as part of the six-foot channel project. The inundated wing dams as well as the backwater areas provide excellent fish and waterfowl habitat. As for recreational boating, there were over 6,000 recreation boat lockages in the year 2000. **Table 7-8** shows a comparison of recreational to towboat lockages.

Table 7-8
Commercial & Recreational Lockages at Lock No. 10

Year	Towboats & Barges	Recreation Lockages	Other Lockages	Total Lockages	Percent Recreation
1991	3,187	2,169	67	5,423	40 %
1992	3,361	2,072	56	5,489	38 %
1993	2,109	1,055	25	3,189	33 %
1994	2,375	2,376	130	4,881	49 %
1995	3,234	2,072	61	5,367	39 %
1996	3,275	1,770	121	5,166	34 %
1997	2,987	1,676	52	4,715	36 %
1998	3,185	2,014	49	5,248	38 %
1999	3,604	1,894	54	5,552	34 %
2000	3,110	1,764	158	5,032	35 %
2001	2,384	1,392	132	3,908	36 %
2002	3,126	1,637	157	4,920	33 %

7-07. Water Quality. The Corps of Engineers does not perform any water quality analysis in Pool No. 10. However, as an element of the Environmental Management Program (EMP), the Corps of Engineers oversees the Long Term Resource Monitoring Program (LTRMP) of the Upper Mississippi River System. The LTRMP was implemented to provide decision makers with the information needed to maintain the Upper Mississippi River System as a viable multiple-use large river ecosystem. The LTRMP is being implemented by the US Geological Survey (USGS) in cooperation with the states of Illinois, Iowa, Minnesota, Missouri and Wisconsin with guidance and overall program responsibility by the Corps of Engineers. There is an active USGS water quality station on the Wisconsin River at Muscoda.

7-08. Fish and Wildlife. Water control activities have immediate as well as long term affects on fish and wildlife resources. These affects can be both positive and negative and thus emergency or planned deviations from normal regulation must be coordinated with appropriate Environmental Resources Branch staff. The wide variety of terrestrial, wetland, and aquatic habitats of Pool 10 supports a diversity of fish, mussel, mammal, bird, reptile, and amphibian species. The pool supports an important sport fishery as well as commercially harvested fish species and river bottomlands serve as breeding areas for many species of marsh dwelling birds (i.e. ducks, geese, swans, herons) while backwaters provide feeding habitat for wading birds such as great blue heron, double-crested cormorant, and great egret.

One species listed for federal protection, bald eagle (*Haliaetus leucocephalus*), is present in Pool 10. Several active bald eagle nest sites exist in the pool and the pool also provides suitable wintering habitat. Several mussel species listed for protection in Iowa and Wisconsin exist in Pool 10, including one species, Higgins eye pearlymussel (*Lampsilis higginsii*), which is also listed as federally endangered. The Higgins Eye Recovery Team has designated ten "Essential Habitat Areas" that contain viable reproducing Higgins eye populations and are crucial for the conservation of the species. Three of these areas are within Pool 10 including 1) Harpers Slough, 2) Main and East Channels at Prairie du Chien, Wisconsin, and Marquette, Iowa, and 3) McMillan Island.

Part of the Upper Mississippi River National Wildlife and Fish Refuge is located in Pool No. 10 and includes all but the navigation channel. The Refuge was established in 1924 to preserve the Upper Mississippi River for fish, migratory birds, other wildlife, and people. The Refuge includes acreage acquired by the US Fish and Wildlife Service and land acquired during the 1930's by the Corps of Engineers for the construction of the nine-foot navigation channel. Today, the refuge consists of about 200,000 acres of wooded islands, forest, prairie, marsh, and water extending 261 miles southward from Wabasha, Minnesota to just above Rock Island, Illinois.

Until 1960, during low to moderate flows, the only water flowing into Pool No. 11 was passed through the dam. At that time, the spillway was notched to provide aeration to backwater areas downstream of the dam. At project pool elevation of 611.0 feet, a continuous flow of 135 cfs is maintained through the notched spillway.

Because the lock and dam was constructed for the purpose of navigation, the pool would sometimes be drawn down in non-navigation season. The 1948 Anti-Drawdown Law prevented any winter drawdown of the pool. The pool was to be regulated the same as during navigation season. A higher stage in the backwater areas during the winter months reduces the oxygen depletion. Because of this, Water Control typically operates on the high side of the winter band.

7-09. Water Supply. The cities and towns of Guttenberg, Clayton, Harpers Ferry, McGregor, Marquette, Iowa and Bagley, Glen Haven, Prairie du Chien, and Wyalusing, Wisconsin obtain their water from municipal or private wells. Pool No. 10 does not provide water supply.

7-10. Hydroelectric Power. There is no hydroelectric power at Lock and Dam No. 10.

7-11. Navigation. The primary purpose of Lock and Dam No. 10 is to provide navigation. The lock is 110 feet wide and 600 feet long. In a single lockage, this will accommodate a towboat (about the same length as a barge) and two rows of three barges (typically 35 ft by 195 ft). On a double lockage, a maximum of 15 barges can be locked through. The first nine barges (three rows of three) enter the lock chamber and are broken free of the remainder. The haulage unit moves these through the lock and they are then tied to the guidewall. The towboat with the remaining six barges (two rows of three) passes through the lock and is rejoined with the nine other barges. Filling and emptying time for the lock under normal conditions is eight minutes. Lockage time for a double lockage depends on the experience of the deck hands breaking and making couplings, number of loaded and empty barges, wind speed and direction, flow conditions, and whether it is an up bound or down bound tow. A down bound tow will take longer due to outdraft conditions at the dam. On average, a double lockage takes about 1 hour and 30 minutes.

7-12. Emergency Action Plans. The Emergency Action Plan is a stand-alone document entitled *Emergency Plan for Lock and Dam 10, Guttenberg, Iowa*, June 1995. The plan addresses emergencies related to above normal reservoir water levels and/or rapid release of large volumes of water past the dam. It covers identification of impending or existing emergencies and notification of other parties concerning impending or existing emergencies. Potential causes of an emergency affecting the operation or safety of Lock and Dam No. 10 include excess seepage, sabotage, extreme storm, failure of foundation, abutment and equipment, and slope failure.

Other emergency situations not addressed in the Emergency Action Plan are barge incidents and chemical spills. When a barge or barges go into the dam, Water Control is to be notified as soon as possible. Most likely, the manipulation of gates will be necessary to accommodate removal of the barge(s). All gate movements are to be coordinated with Water Control to reduce the potential for erosion of the channel bottom downstream of the dam. In the event of a chemical spill resulting from a barge incident or other disaster, the Lockmaster is to immediately notify the National Response Center. The telephone number is on the Emergency Notification Chart at the site. The Lockmaster is also to notify Water Control (651-290-5624) and the Emergency Operations Center (EOC) at 651-290-5220. Water Control will coordinate with the lock site as well as Emergency Management and Environmental Branch.

There are several protective measures taken at Lock and Dam No. 10 when a flood occurs. When the pool level is forecasted to go above elevation 614.0 feet (1912 adjustment) material used to protect the earthen dike is to be stockpiled. As the pool continues to rises other actions are required. The following gives a brief summary of the steps to be taken as water levels go higher.

Table 7-9
Flood Action Plan

Pool Elevation	**Action Taken**
614.0 feet	Control seepage in Central Control Station (CCS); Pump transformer unit.
615.0 feet	Plug incoming conduit holes.
616.0 feet	Close upper slope esplanade drain.
618.3 feet	Protect fuel storage tanks.
620.0 feet	Sandbag manholes on lock walls.
621.8 feet	Control seepage – dwelling basement.
622.0 feet	Raise dike.
623.0 feet	Sandbag manholes for sewer system.
624.0 feet	Remove miter gate handrails; secure gratings; Sandbag CCS and shop; Diversion dike – upper slope to Miter Gate #2; Dike from Miter Gate #1 to lower slope; Protect upper haulage motor.
625.0 feet	Protect lower haulage motor.
628.0 feet	Sandbag dwellings.

7-13. Other. During a flood event, debris is passed beneath the gates as they are typically raised clear of the water. Debris that hangs up around the tainter gates may require assistance. This is handled after the peak has passed.

7-14. Deviation from Normal Regulation. Congress mandates project pool elevation. While in primary control, the pool is to be maintained at elevation 611.0 ± 0.2 feet at the primary control point (Lock and Dam No. 10) as best as possible. During low flows, the pool is not to be intentionally raised above or lowered below this elevation; however, temporary deviations are permitted. Because these deviations are unplanned and are only temporary, while actions are being taken to correct the situation, these exceptions do not require notification to the Division Office. The Mississippi Valley Division office (MVD) must be notified when deviation outside the limits set by primary and secondary control is intentional and for a prolonged period of time. Planned deviations must be coordinated with the District's Environmental Branch. Once the plan is coordinated within the District, it may be submitted to Division Water Control Manager for approval. Minor deviations may be approved by email whereas major deviations will require a written request. All deviation requests should describe cause and effect. MVD will decide if the deviation is major or minor. The District Commander or Chief of Engineering Division may deviate from the approved plan in an emergency situation. The District is to inform MVD as soon as possible with a written confirmation of the deviation and description of the cause.

7-15. Rate of Release Change. The only guideline for rate of release change is the "ten percent rule" (**Section 7-04**). During Water Control's non-duty hours, lock and dam personnel may only make a gate change to remain within the prescribed band such that it does not exceed ten percent of the total flow. There are no other guidelines for rate of release change. Operation of the dam is basically run of the river. Therefore, rate of release change is nature driven.

VIII – EFFECT OF WATER CONTROL PLAN

8-01. General. The effect of the water control plan for Lock and Dam No. 10 is to maintain a nine-foot depth in the navigation channel of Pool No. 10. Lock and Dam No. 10 is just one piece of the lock and dam system that provides navigation from St. Louis, Missouri to Minneapolis, Minnesota. Navigation on the Upper Mississippi River progressed from a four-foot deep channel in 1866, to a four and one-half foot channel in 1878, to a six-foot channel in 1907, and finally, to a nine-foot channel in 1930's. A more complete description of this development is available in the Master Water Control Manual for the Locks and Dams.

8-02. Flood Control. The locks and dams provide no flood control benefits. They were constructed strictly for navigation purposes. The dam operates on a run-of-the-river principle. As discharge increases, the gates are opened. At around 78,000 cfs the gates are raised clear of the water surface. Therefore, for flood events, the only impact on the flow line is the swellhead at the dam, which is less than one foot.

8-03. Recreation. The project is not regulated for recreation purposes; however, it does provide recreational benefits. The three recreation qualities associated with Pool No. 10 are fishing, hunting, and boating. Project pool inundated the wing dams, constructed as part of the six-foot navigation project, and created backwater areas, which provide good fish and waterfowl habitat. While Lock and Dam No. 10 provides the necessary depths for the towing industry, it also is a benefit to recreational boating. The more stable water surface provides a more suitable environment for docks and marinas. There were over 1,600 recreation boat lockages in the year 2002.

8-04. Fish and Wildlife. The effects of construction and continued operation and maintenance of the 9-foot channel has been previously described (USACE 1974, GREAT I 1980) and is incorporated by reference and summarized below. No changes in the water control manual are being proposed with this update that have not been previously assessed in those documents.

Construction of the 9-foot channel and the preceding construction of numerous channel training structures as part of the 3-, 4.5- and 6-foot channel projects had a profound effect on river hydrodynamic conditions and significantly altered habitat conditions within the Upper Mississippi River (UMR) floodplain. The significant increase in aquatic area and more lake-like conditions created by the series of impoundments resulted in an explosion of aquatic vegetation and associated fish and wildlife. However, the UMR is undergoing the aging process that most reservoirs experience over time. Sedimentation of shallow aquatic and wetland areas particularly in the middle reaches of UMR pools is occurring and the low lying islands in the lower reaches of the pool are eroding. The prolonged inundation and stable water levels are also affecting the quality and quantity of aquatic vegetation. As with other UMR pools, while retaining many of the attributes of an unregulated river primarily in the upper reaches of a pool, the present day Pool No. 10 supports scattered remnant patches of relatively undisturbed river habitats.

The water control plan for Pool No. 10 will have a major affect on mussels in general and the federally endangered Higgins eye pearlymussel in particular by facilitating the persistence and continued upstream transport by barge and recreational traffic of the exotic zebra mussel (*Dreissena polymorpha*). Zebra mussels favor lentic conditions and attach to natural substrates, such as rocks, native mussels, wood, and aquatic plants. They affect native mussels by competing for food and by attaching to mussels in such numbers that infested mussels cannot travel or burrow.

8-05. Navigation. The Upper Mississippi River Nine-Foot Channel Project originated in the 1920's when it was promoted as a way to alleviate the Nation's worsening farm crisis. It was also aimed at allaying the inequities in commercial rail and water freight rates. The project was authorized by the Rivers and Harbors Act of 1930, with most of the locks and dams, including Lock No. 10, being constructed in the 1930's. The project was not without its controversy. For example, railroads claiming damage to their right-of-ways and conservationists fearing its effects on the environment. Ultimately, the economic benefits overrode all other concerns. After completion of the project, river traffic increased from 2,400,000 tons in 1939 to 68,400,000 tons in 1976. **Table 8-1** shows the recent history of tonnage commodities at Lock and Dam No. 10. For more historical information concerning the Nine-Foot Channel Project, see the Master Water Control Manual for the Locks and Dams.

Table 8-1
Lock and Dam No. 10 Tonnage – Commodities

Year	Coal	Petrol Product	Chemical Products	Crude Material	Manu Goods	Farm Products	Equip Mach	Misc Product	Total Tonnage
1991	2,302,100	713,500	1,693,800	808,300	606,700	12,862,500	0	24,700	19,011,600
1992	2,229,300	446,200	1,966,000	1,070,100	586,400	13,590,800	12,500	22,500	19,923,800
1993	2,088,900	194,800	2,041,800	1,008,200	408,800	6,775,800	13,100	18,300	12,549,700
1994	2,400,400	230,000	2,373,600	1,035,200	618,400	8,337,600	12,100	40,500	15,047,800
1995	2,367,700	545,100	1,890,300	1,088,400	628,000	11,622,900	25,800	136,400	18,304,600
1996	2,469,400	433,900	1,929,800	1,126,600	424,500	12,377,000	7,600	78,300	18,847,100
1997	2,349,800	517,600	1,702,500	1,474,900	563,400	11,063,000	10,300	135,200	17,816,700
1998	3,100,700	844,700	1,933,400	1,280,800	866,000	11,227,100	9,700	65,900	19,328,300
1999	3,245,100	572,200	1,659,300	1,214,500	1,055,400	14,127,400	13,900	118,800	22,006,600
2000	2,849,813	613,430	2,017,657	1,213,205	860,085	12,056,013	3,200	297,811	19,911,214
2001	2,520,433	184,073	1,727,764	1,635,848	643,863	9,559,124	6,228	232,581	16,509,914
2002	2,750,116	425,617	1,893,011	1,613,132	849,819	12,690,014	14,195	292,988	20,528,892

8-06. Frequencies. St. Paul District developed a discharge-frequency relationship in 2002 for the gaging station at McGregor, Iowa. The McGregor gage is about 18.4 miles upstream of Lock and Dam No. 10. The frequency curve displayed in **Figure 8-1** represents peak flow relationships for the Mississippi River at river mile 633.5. The frequency curve is derived from regionalized statistics for the mean and standard deviation, based on drainage area relationships at this location.

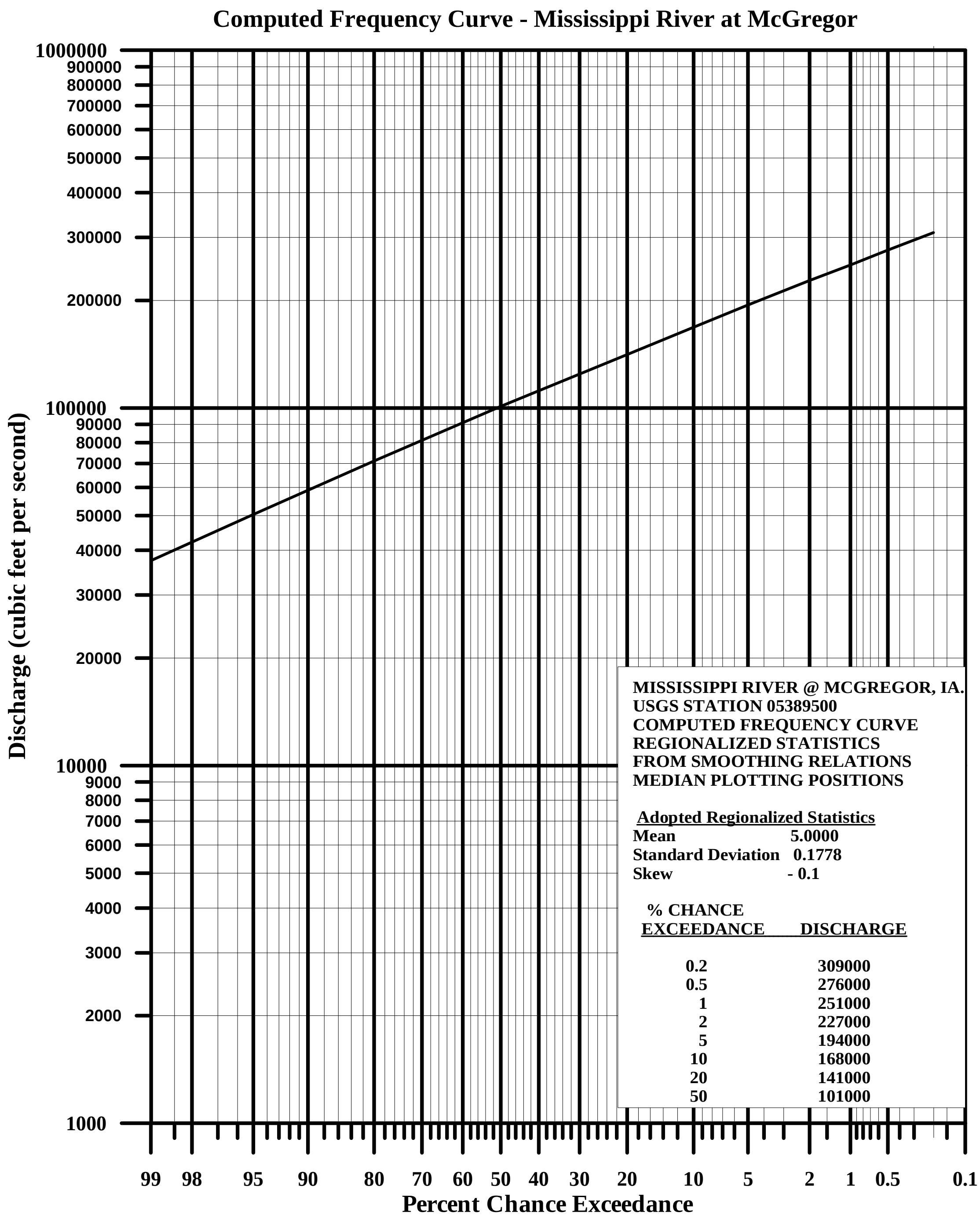


Figure 8-1. Discharge Frequency – Mississippi River at McGregor

Construction of the dam was completed in December 1936. By March 1938, project pool elevation was achieved. The following shows a history of the pool elevation. The high elevations represent flood events and the lows represent drawdown at the dam (typically secondary control). When in secondary control, the pool elevation at the dam was allowed to be drawn down 2 feet below project pool level to elevation 609.0 feet (1912 adjustment) until 1971 when maximum drawdown was established at elevation 610.0 feet. Prior to the Anti-Drawdown Law, passed by Congress in 1948, the pools were sometimes drawn down below primary and secondary elevations during the winter months. The greatest drawdown occurred in January 1944 when the pool was drawn down to elevation 603.86 feet.

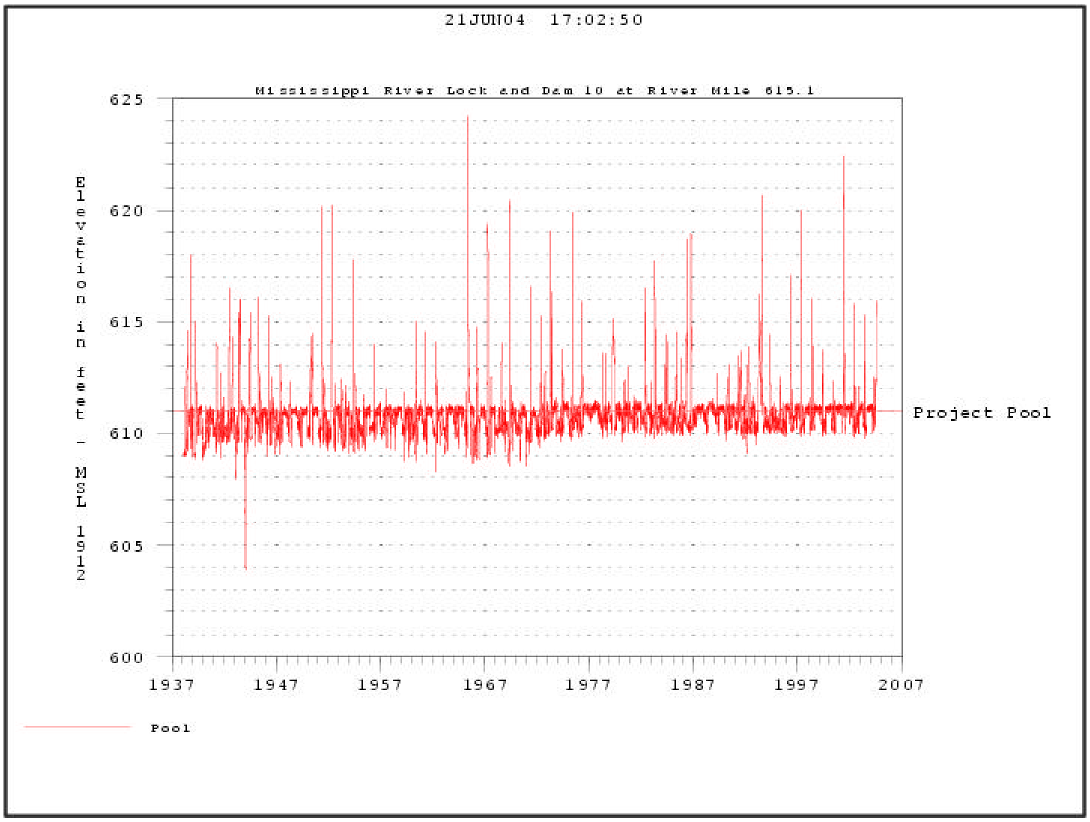


Figure 8-2. History of Pool Elevation

Water surface profile frequencies were developed in 2003 as part of the 2003 Flow Frequency Study. **Plate 8-1** shows the water surface profiles for 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year floods in Pool No. 9 and 10. Also included is the profile for the flood of 1965.

IX – WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. Corps of Engineers. The Corps of Engineers is the owner, operator, and regulator for Lock and Dam No. 10. The St. Paul District, Water Control and Hydrology Section has direct day-to-day responsibility for gate adjustments at the dam. Operations Division is responsible for operation and maintenance of the lock and the dam. The following shows the working relationship for the locks and dams within the St. Paul District.

St. Paul District Office
← ← ← **District Engineer** → → →

↓	↓
Chief, Eng & Const Division	**Chief, Operations Division**
↓	↓
Chief H&H Branch	**Chief Lock & Dam Project Office**
↓	↓
Chief Water Control & Hyd Section	**Area Lockmaster**
↓	↓

Water Control Manager → → → → → **Lockmaster**

b. Other Federal Agencies. During high water, the National Weather Service (NWS) forecasts stage heights for McGregor, Iowa and for Guttenberg, Iowa. The Guttenberg gage is actually the tailwater gage for Lock and Dam No. 10. Water Control Section provides the NWS with the daily output from the Mississippi Basin Modeling System to aid them in making their forecast.

The Wisconsin US Geological Survey (USGS) maintains the Corps of Engineers (COE) gage sites for the Wisconsin River at Muscoda and the Kickapoo River at Steuben. The Iowa USGS maintains the COE gage sites on the Mississippi River at McGregor, Iowa and Clayton, Iowa. Hourly stage and discharge values for Muscoda, Steuben, and McGregor, and stage heights for Clayton, can be obtained from the USGS link on the Water Control web site at *www.mvp-wc.usace.army.mil*.

The US Fish and Wildlife Service (USFWS) operates and maintains the Upper Mississippi River National Wildlife and Fish Refuge, a portion of which is located in Pool No. 10.

9-02. Interagency Coordination.

a. Local Press and Corps Bulletins. Information concerning regulation of Lock and Dam No. 10 is provided by the St. Paul District's Public Affairs Office (PAO) to the local news media in response to their requests. In addition, Construction and Operations Division coordinates with PAO to provide News Releases regarding the opening or closing of the lock to navigation.

b. National Weather Service. By 0830-hours each day, the National Weather Service (NWS) electronically transfers to Water Control the five-day forecast stage-hydrographs for tributaries to the Mississippi River lock and dam system. The five-day forecast includes the 24-hour quantitative precipitation forecast (QPF). Water Control inputs these hydrographs to the Mississippi Basin Modeling System (MBMS), which is an unsteady flow model utilizing the computer program UNET. The MBMS produces a 30-day forecast for the locks and dams and points of interest along the Mississippi River. The forecast is based on the water that is already in the system plus the NWS's 24-hour QPF. Output from the model is sent to the NWS around 0930-hours. The NWS uses this information to forecast stages along the Mississippi River, which includes McGregor, Iowa, and Guttenberg, Iowa (tailwater of Lock and Dam No. 10).

c. US Geological Survey. To maintain the vast network of stream gages for operation of the locks and dams in the St. Paul District would be a costly undertaking. Because of the existing infrastructure of the US Geological Survey (USGS), the St. Paul District enters into a cooperative agreement each year with the USGS maintain many of the gages on the Mississippi River and its tributaries. As for Pool No. 10, this includes the Mississippi River at McGregor, Iowa, the Mississippi River at Clayton, Iowa, the Wisconsin River at Muscoda, Wisconsin and the Kickapoo River at Steuben, Wisconsin. This requires a cooperative agreement with the Wisconsin USGS and the Iowa USGS. St. Paul District owns all the gage equipment except for the Stevens A-35 roll chart at the McGregor gage. The Iowa USGS publishes the daily discharges for Mississippi River at the McGregor and Clayton gages annually as part of their *Water Resources Data – Iowa*. The Wisconsin USGS annually publishes the daily discharge for the Kickapoo River at Steuben and the Wisconsin River at Muscoda as part of their *Water Resources Data – Wisconsin*. Daily data can be obtained through the USGS link on the Water Control web site at *www.mvp-wc.usace.army.mil*.

d. US Fish and Wildlife Service. The St. Paul District, in coordination with the US Fish and Wildlife Service, has constructed a number of habitat restoration projects in Pool No. 10, including the Bussey Lake, Guttenberg Waterfowl Ponds, Ambrough Slough, and Mississippi River Bank Stabilization habitat projects. See **Section 2-04** for photos and descriptions of the habitat projects.

e. River Resources Forum. The River Resources Forum and the subcommittee, Water Level Management Task Force, shares information and provides recommendations to the Corps of Engineers on river management. Participants include the US Fish and Wildlife Service, US Geological Survey, US Environmental Protection Agency, National Park Service, US Coast Guard, US Department of Transportation, Departments of Natural Resources for Minnesota, Wisconsin and Iowa, Departments of Transportation for Minnesota and Wisconsin, and representatives of the commercial navigation industry.

9-03. Reports. "Operators Log" Form 2198 is the name for the daily log of river and dam conditions. These are kept at the site. National Weather Service (NWS)

Form B-91 contains pertinent weather information at the lock site. This is mailed to the NWS on the first of each month. The "Stevens Strip Charts" are sent to Water Control section at a minimum of once per year.

EXHIBIT A
SUPPLEMENTARY PERTINENT DATA

General Information

Location:	Mississippi River Mile 615.1 Guttenberg, Iowa Lat 42° 47' 6" N Long 91° 5' 42" W 32.8 miles below Lock and Dam No. 9 32.1 miles above Lock and Dam No. 11
Type of Project:	Lock and Dam for Navigation Purposes
Project Owner:	Corps of Engineers
Operating Agency:	St. Paul District; Construction-Operations Division
Regulating Agency:	St. Paul District; Water Control Section
Completion Date:	December 1936
Datum:	MSL – 1912 adjustment

Hydrology

Drainage Area:	79,370 square miles
Design Flood:	Flood of 1880 Design High Water: Elevation 620.1 ft Design Discharge: 226,000 cfs
Minimum Flow:	Of Record: 1933 Discharge 6,000 cfs Post Construction during Navigation Season: July 1988 Discharge 10,900 cfs
Maximum Flow:	24 April 1965: Discharge 308,000 cfs
Average Annual Flow:	Years 1960-2002: Discharge 49,800 cfs
Maximum Monthly Flow:	April 1965: Discharge 189,200 cfs
Maximum Daily Flow:	23 April 1965: Discharge 305,500 cfs
Key Stream Flow Locations:	Mississippi River @ Clayton, Iowa Mississippi River @ McGregor, Iowa Wisconsin River @ Muscoda, Wisconsin Kickapoo River @ Steuben, Wisconsin

Data Recorded at Dam:	Pool & Tailwater Elevations (4-hr) Clayton and McGregor Elevations (4-hr) Total Discharge (4-hr) Tainter Valve Opening (4-hr, winter only) Gate Openings (4-hr) Wind Speed & Direction (8-hr) Air Temperature (8-hr) Precipitation (daily) Water Temperature (daily) Maximum-Minimum Air Temperature (daily) Snow Depth & Water Content (weekly) Percent Pool & Tailwater Ice Coverage (weekly) Pool & Tailwater Ice Thickness (weekly)
Precipitation Gages:	Lock and Dam No. 10 @ Guttenberg, Iowa Mississippi River @ McGregor, Iowa Wisconsin River @ Muscoda, WI Kickapoo River @ Steuben, Wisconsin
Snow Survey:	Site Personnel - LD No. 10 weekly Water Control Gage Crew – 1st week of March Wisconsin sample sites: Abbotsford, Antigo, Bradley, Cashton, Coloma, Dexterville, Gays Mill, Hillsboro, Marshfield, Mauston, Merrill, Minocqua, Necedah, Oxford, Portage, Reedsburg, Rhinelander, Richland, Center, Stevens Point, Tomah, Viroqua, Wausau, Wittenburg

Physical Features

Lock:	Main Lock Chamber:	110 ft by 600 ft
	Top of Lock Walls:	Elevation 624.0 ft
	Top of Upper Gate Sill (main):	Elevation 596.0 ft
	Top of Upper Gate Sill (aux):	Elevation 591.0 ft
	Top of Lower Gate Sill:	Elevation 591.0 ft
	Lock Chamber Floor:	Elevation 589.0 ft
	Height of Upper Miter Gates (main):	25.0 feet
	Height of Upper Miter Gates (aux):	30.0 feet
	Height of Lower Miter Gates:	8.0 feet
	Lift:	11.0 feet
	Upper Guide Wall Length:	517 feet
	Lower Guide Wall Length:	500 feet
	Freeboard @ Project Pool:	13 feet
	Average Filling/Emptying Time:	8 minutes
	Average Double Lockage Time:	1.5 hours

Moveable Dam:	Roller Gates: 4 Gates	80 feet by 20 feet
	Tainter Gates: 8 Gates	40 feet by 20 feet
	Roller Gate Sill:	Elevation 591.0 ft
	Tainter Gate Sill:	Elevation 591.0 ft
	Roller Gate End Sill (average):	Elevation 589.2 ft
	Tainter Gate End Sill (average):	Elevation 591.3 ft
	Roller Gate Submergence:	Not submergible
	Tainter Gate Submergence:	
	Gates No. 1 and 12	3 feet below PP
	Bulkheads:	
	Roller Gates:	6 @ 4.0' by 82.64'
	Tainter Gates:	14 @ 1.72' by 42.50'
	Top of Bridge Deck:	Elevation 643.11 ft
Earthen Dam:	Length:	4,547 feet
	Crest Elevation:	624.0 ft
	Top Width:	20 feet
	Maximum Height:	28 feet
	Pool Side Slope:	1V:3H
	Tailwater Slope:	1V:4H
	Slope Protection:	18 inch riprap
	Pool side:	Toe to Crest
	TW side:	Toe to elevation 614.0 ft
	Ogee Spillway:	
	Length:	1,200 feet
	Crest Elevation:	611.0 ft (1912)
	Notches in Spillway:	2 @ 5 ft wide by 3 ft deep
	Flow @ Project Pool:	135 cfs
Pool:	Normal (Project) Upper Pool:	Elevation 611.0 ft
	Normal (Project) Lower Pool:	Elevation 603.0 ft
	Total Pool Area (at Project Pool):	17,070 acres
	Primary Control Point (dam):	Elevation 611.0 ft
	Secondary Control Point (Clayton):	Elevation 611.8 ft
	Tertiary Control Point (dam)	Elevation 610.0 ft
	Length in River Miles:	32.8 miles
	Navigation Channel Width;	
	Straight Reaches:	300 feet
	Curved Reaches:	300-550 feet
	Most Frequent Dredge Site:	McMillan Island

EXHIBIT B
Wisconsin River at Muscoda Rating Table

U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION NUMBER 05407000 WISCONSIN RIVER AT MUSCODA, WI SOURCE AGENCY USGS STATE 55 COUNTY 043
LATITUDE 431153 LONGITUDE 0902636 NAD27 DRAINAGE AREA 10400.00 CONTRIBUTING DRAINAGE AREA DATUM 666.77 NGVD29
Date Processed: 2003-09-11 10:29 By rjwaschb
Rating for Discharge, IN cfs
RATING ID: 28.0 TYPE: stage-discharge EXPANSION: linear STATUS: approved
Created by twittwer on 11-26-2002 @ 04:04:02 CST, Updated by twittwer on 11-26-2002 @ 04:04:02 CST
Remarks: JH 9/3/93

EXPANDED RATING TABLE

Gage height, feet	Discharge IN cfs .00	.01	.02	.03	.04	(STANDARD PRECISION) .05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
0.60	3040*	3060	3080	3110	3130	3150	3170	3190	3220	3240	220
0.70	3260	3280	3300	3330	3350	3370	3390	3410	3440	3460	220
0.80	3480	3500	3520	3550	3570	3590	3610	3630	3660	3680	220
0.90	3700*	3720	3750	3770	3800	3820	3840	3870	3890	3920	240
1.00	3940*	3970	3990	4020	4040	4070	4100	4120	4150	4170	260
1.10	4200*	4230	4250	4280	4310	4340	4360	4390	4420	4440	270
1.20	4470*	4500	4530	4550	4580	4610	4640	4670	4690	4720	280
1.30	4750*	4780	4810	4840	4870	4900	4930	4960	4990	5020	300
1.40	5050	5080	5110	5140	5170	5200	5230	5260	5290	5320	300
1.50	5350	5380	5410	5440	5470	5500	5530	5560	5590	5620	300
1.60	5650*	5680	5710	5750	5780	5810	5840	5870	5910	5940	320
1.70	5970	6000	6030	6070	6100	6130	6160	6190	6230	6260	320
1.80	6290*	6320	6360	6390	6420	6460	6490	6520	6550	6590	330
1.90	6620	6650	6690	6720	6750	6790	6820	6850	6880	6920	330
2.00	6950*	6980	7020	7050	7090	7120	7150	7190	7220	7260	340
2.10	7290*	7330	7360	7400	7430	7470	7500	7540	7570	7610	350
2.20	7640*	7680	7710	7750	7780	7820	7860	7890	7930	7960	360
2.30	8000	8040	8070	8110	8140	8180	8220	8250	8290	8320	360
2.40	8360	8400	8430	8470	8500	8540	8580	8610	8650	8680	360
2.50	8720*	8760	8800	8830	8870	8910	8950	8990	9020	9060	380
2.60	9100	9140	9180	9210	9250	9290	9330	9370	9400	9440	380
2.70	9480	9520	9560	9590	9630	9670	9710	9750	9780	9820	380
2.80	9860	9900	9940	9970	10000	10100	10100	10100	10200	10200	340
2.90	10200	10300	10300	10400	10400	10400	10500	10500	10500	10600	400
3.00	10600	10700	10700	10700	10800	10800	10800	10900	10900	11000	400
3.10	11000*	11000	11100	11100	11200	11200	11200	11300	11300	11400	400
3.20	11400	11400	11500	11500	11600	11600	11600	11700	11700	11800	400
3.30	11800*	11800	11900	11900	12000	12000	12100	12100	12200	12200	500
3.40	12300	12300	12300	12400	12400	12500	12500	12600	12600	12700	400

Gage height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
	Discharge IN cfs					(STANDARD PRECISION)					
3.50	12700	12700	12800	12800	12900	12900	13000	13000	13100	13100	500
3.60	13200	13200	13200	13300	13300	13400	13400	13500	13500	13600	400
3.70	13600*	13700	13700	13800	13800	13900	13900	14000	14000	14100	500
3.80	14100	14200	14200	14300	14300	14400	14400	14500	14500	14600	500
3.90	14600	14700	14700	14800	14800	14900	14900	15000	15000	15100	500
4.00	15100	15200	15200	15300	15300	15400	15400	15500	15500	15600	500
4.10	15600	15700	15700	15800	15800	15900	15900	16000	16000	16100	500
4.20	16100	16200	16200	16300	16300	16400	16400	16500	16500	16600	500
4.30	16600	16700	16700	16800	16800	16900	16900	17000	17000	17100	500
4.40	17100	17200	17200	17300	17300	17400	17400	17500	17500	17600	500
4.50	17600	17700	17700	17800	17800	17900	17900	18000	18000	18100	500
4.60	18100	18200	18200	18300	18300	18400	18400	18500	18500	18600	500
4.70	18600	18700	18700	18800	18800	18900	18900	19000	19000	19100	500
4.80	19100	19200	19200	19300	19300	19400	19400	19500	19500	19600	500
4.90	19600	19700	19700	19800	19800	19900	19900	20000	20000	20100	500
5.00	20100	20200	20200	20300	20300	20400	20400	20500	20500	20600	500
5.10	20600	20700	20700	20800	20800	20900	20900	21000	21000	21100	500
5.20	21100	21200	21200	21300	21300	21400	21400	21500	21500	21600	500
5.30	21600	21700	21700	21800	21800	21900	21900	22000	22000	22100	500
5.40	22100*	22200	22200	22300	22300	22400	22400	22500	22500	22600	600
5.50	22700	22700	22800	22800	22900	22900	23000	23000	23100	23100	500
5.60	23200	23300	23300	23400	23400	23500	23500	23600	23600	23700	600
5.70	23800	23800	23900	23900	24000	24000	24100	24100	24200	24200	500
5.80	24300	24400	24400	24500	24500	24600	24600	24700	24700	24800	600
5.90	24900	24900	25000	25000	25100	25100	25200	25200	25300	25300	500
6.00	25400	25500	25500	25600	25600	25700	25700	25800	25800	25900	600
6.10	26000	26000	26100	26100	26200	26200	26300	26300	26400	26400	500
6.20	26500*	26600	26600	26700	26700	26800	26900	26900	27000	27000	600
6.30	27100	27200	27200	27300	27300	27400	27500	27500	27600	27600	600
6.40	27700	27800	27800	27900	27900	28000	28100	28100	28200	28200	600
6.50	28300	28400	28400	28500	28500	28600	28700	28700	28800	28800	600
6.60	28900*	29000	29000	29100	29200	29300	29300	29400	29500	29500	700
6.70	29600	29700	29700	29800	29900	30000	30000	30100	30200	30200	700
6.80	30300	30400	30400	30500	30600	30700	30700	30800	30900	30900	700
6.90	31000	31100	31100	31200	31300	31400	31400	31500	31600	31600	700

Gage height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
	Discharge IN cfs					(STANDARD PRECISION)					
7.00	31700	31800	31800	31900	32000	32100	32100	32200	32300	32300	700
7.10	32400	32500	32500	32600	32700	32800	32800	32900	33000	33000	700
7.20	33100	33200	33200	33300	33400	33500	33500	33600	33700	33700	700
7.30	33800	33900	33900	34000	34100	34200	34200	34300	34400	34400	700
7.40	34500	34600	34600	34700	34800	34900	34900	35000	35100	35100	700
7.50	35200	35300	35300	35400	35500	35600	35600	35700	35800	35800	700
7.60	35900	36000	36000	36100	36200	36300	36300	36400	36500	36500	700
7.70	36600*	36700	36800	36800	36900	37000	37100	37200	37200	37300	800
7.80	37400	37500	37600	37600	37700	37800	37900	38000	38000	38100	800
7.90	38200	38300	38400	38400	38500	38600	38700	38800	38800	38900	800
8.00	39000	39100	39200	39200	39300	39400	39500	39600	39600	39700	800
8.10	39800	39900	40000	40000	40100	40200	40300	40400	40400	40500	800
8.20	40600	40700	40800	40800	40900	41000	41100	41200	41200	41300	800
8.30	41400	41500	41600	41600	41700	41800	41900	42000	42000	42100	800
8.40	42200	42300	42400	42400	42500	42600	42700	42800	42800	42900	800
8.50	43000	43100	43200	43200	43300	43400	43500	43600	43600	43700	800
8.60	43800	43900	44000	44000	44100	44200	44300	44400	44400	44500	800
8.70	44600	44700	44800	44800	44900	45000	45100	45200	45200	45300	800
8.80	45400*	45500	45600	45700	45800	45900	45900	46000	46100	46200	900
8.90	46300	46400	46500	46600	46700	46800	46800	46900	47000	47100	900
9.00	47200	47300	47400	47500	47600	47700	47700	47800	47900	48000	900
9.10	48100	48200	48300	48400	48500	48600	48600	48700	48800	48900	900
9.20	49000	49100	49200	49300	49400	49500	49500	49600	49700	49800	900
9.30	49900	50000	50100	50200	50300	50400	50400	50500	50600	50700	900
9.40	50800	50900	51000	51100	51200	51300	51300	51400	51500	51600	900
9.50	51700	51800	51900	52000	52100	52200	52200	52300	52400	52500	900
9.60	52600	52700	52800	52900	53000	53100	53100	53200	53300	53400	900
9.70	53500	53600	53700	53800	53900	54000	54000	54100	54200	54300	900
9.80	54400	54500	54600	54700	54800	54900	54900	55000	55100	55200	900
9.90	55300	55400	55500	55600	55700	55800	55800	55900	56000	56100	900
10.00	56200*	56300	56400	56500	56600	56700	56800	56900	57000	57100	1000
10.10	57200	57300	57400	57500	57600	57700	57800	57900	58000	58100	1000
10.20	58200	58300	58400	58500	58600	58700	58800	58900	59000	59100	1000
10.30	59200	59300	59400	59500	59600	59700	59800	59900	60000	60100	1000
10.40	60200	60300	60400	60500	60600	60700	60800	60900	61000	61100	1000

Gage height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
	Discharge IN cfs					(STANDARD PRECISION)					
10.50	61200	61300	61400	61500	61600	61700	61800	61900	62000	62100	1000
10.60	62200	62300	62400	62500	62600	62700	62800	62900	63000	63100	1000
10.70	63200	63300	63400	63500	63600	63700	63800	63900	64000	64100	1000
10.80	64200	64300	64400	64500	64600	64700	64800	64900	65000	65100	1000
10.90	65200	65300	65400	65500	65600	65700	65800	65900	66000	66100	1000
11.00	66200*										

"*" indicates a rating descriptor point

Rating Type: Rating Type: stage-discharge

ID	Starting Date	Ending Date	A	Comments
28.0	10-01-1992 @ 01:00:00 CDT	09-30-2002 @ 23:59:59 CDT	A	
28.0	10-01-2002 @ 00:00:00 CDT	-----	W	

EXHIBIT C

Kickapoo River at Steuben Rating Table

U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION NUMBER 05410490 KICKAPOO RIVER AT STEUBEN, WI SOURCE AGENCY USGS STATE 55 COUNTY 023
LATITUDE 431058 LONGITUDE 0905130 NAD27 DRAINAGE AREA 687.00 CONTRIBUTING DRAINAGE AREA DATUM 657.00 NGVD29
Date Processed: 2003-09-11 10:35 By rjwaschb
Rating for Discharge, IN cfs
RATING ID: 28.0 TYPE: stage-discharge EXPANSION: linear STATUS: approved
Created by SAMARCH on 12-10-1992 @ 02:11:02 CST, Updated by SAMARCH on 12-10-1992 @ 02:11:02 CST
Remarks: SAME AS RATING NO. 27 BELOW 7.4 FT

EXPANDED RATING TABLE

Gage height, feet	Discharge IN cfs .00	.01	.02	.03	.04	(STANDARD PRECISION) .05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
5.20	213*	215	216	218	219	221	222	224	225	227	15.0
5.30	228	230	231	233	234	236	237	239	240	242	15.0
5.40	243	245	246	248	249	251	252	254	255	257	15.0
5.50	258	260	261	263	264	266	267	269	270	272	15.0
5.60	273	275	276	278	279	281	282	284	285	287	15.0
5.70	288	290	291	293	294	296	297	299	300	302	15.0
5.80	303	305	306	308	309	311	312	314	315	317	15.0
5.90	318	320	321	323	324	326	327	329	330	332	15.0
6.00	333	335	336	338	339	341	342	344	345	347	15.0
6.10	348	350	351	353	354	356	357	359	360	362	15.0
6.20	363	365	366	368	369	371	372	374	375	377	15.0
6.30	378	380	381	383	384	386	387	389	390	392	15.0
6.40	393	395	396	398	399	401	402	404	405	407	15.0
6.50	408	410	411	413	414	416	417	419	420	422	15.0
6.60	423	425	426	428	429	431	432	434	435	437	15.0
6.70	438*	440	441	443	444	446	448	449	451	452	16.0
6.80	454	456	457	459	460	462	464	465	467	468	16.0
6.90	470	472	473	475	476	478	480	481	483	484	16.0
7.00	486	488	489	491	492	494	496	497	499	500	16.0
7.10	502*	504	506	507	509	511	513	515	516	518	18.0
7.20	520	522	524	525	527	529	531	533	534	536	18.0
7.30	538	540	542	543	545	547	549	551	552	554	18.0
7.40	556	558	560	561	563	565	567	569	570	572	18.0
7.50	574	576	578	579	581	583	585	587	588	590	18.0
7.60	592	594	596	597	599	601	603	605	606	608	18.0
7.70	610	612	614	615	617	619	621	623	624	626	18.0
7.80	628	630	632	633	635	637	639	641	642	644	18.0
7.90	646	648	650	651	653	655	657	659	660	662	18.0

Gage height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
	Discharge IN cfs					(STANDARD PRECISION)					
8.00	664	666	668	669	671	673	675	677	678	680	18.0
8.10	682	684	686	687	689	691	693	695	696	698	18.0
8.20	700*	702	704	706	708	710	712	714	716	718	20.0
8.30	720	722	724	726	728	730	732	734	736	738	20.0
8.40	740	742	744	746	748	750	752	754	756	758	20.0
8.50	760	762	764	766	768	770	772	774	776	778	20.0
8.60	780	782	784	786	788	790	792	794	796	798	20.0
8.70	800	802	804	806	808	810	812	814	816	818	20.0
8.80	820	822	824	826	828	830	832	834	836	838	20.0
8.90	840	842	844	846	848	850	852	854	856	858	20.0
9.00	860	862	864	866	868	870	872	874	876	878	20.0
9.10	880	882	884	886	888	890	892	894	896	898	20.0
9.20	900	902	904	906	908	910	912	914	916	918	20.0
9.30	920	922	924	926	928	930	932	934	936	938	20.0
9.40	940*	942	944	947	949	951	953	955	958	960	22.0
9.50	962	964	966	969	971	973	975	977	980	982	22.0
9.60	984	986	988	991	993	995	997	999	1000	1000	26.0
9.70	1010	1010	1010	1010	1010	1020	1020	1020	1020	1030	20.0
9.80	1030	1030	1030	1030	1040	1040	1040	1040	1050	1050	20.0
9.90	1050*	1050	1060	1060	1060	1060	1070	1070	1070	1070	30.0
10.00	1080	1080	1080	1080	1090	1090	1090	1090	1100	1100	20.0
10.10	1100	1100	1110	1110	1110	1120	1120	1120	1120	1130	30.0
10.20	1130	1130	1130	1140	1140	1140	1140	1150	1150	1150	20.0
10.30	1150	1160	1160	1160	1160	1170	1170	1170	1170	1180	30.0
10.40	1180*	1180	1190	1190	1190	1200	1200	1200	1200	1210	30.0
10.50	1210	1210	1220	1220	1220	1230	1230	1230	1230	1240	30.0
10.60	1240	1240	1250	1250	1250	1260	1260	1260	1260	1270	30.0
10.70	1270	1270	1280	1280	1280	1290	1290	1290	1290	1300	30.0
10.80	1300	1300	1310	1310	1310	1320	1320	1320	1320	1330	30.0
10.90	1330*	1330	1340	1340	1350	1350	1350	1360	1360	1370	40.0
11.00	1370	1370	1380	1380	1390	1390	1390	1400	1400	1410	40.0
11.10	1410	1410	1420	1420	1430	1430	1430	1440	1440	1450	40.0
11.20	1450*	1460	1460	1470	1470	1480	1480	1490	1490	1500	50.0
11.30	1500	1510	1510	1520	1520	1530	1530	1540	1540	1550	50.0
11.40	1550	1560	1560	1570	1570	1580	1580	1590	1590	1600	50.0

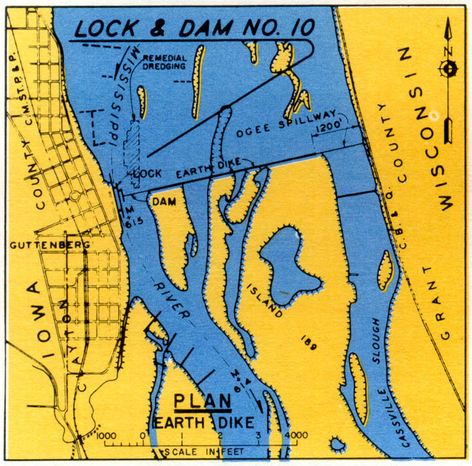
Gage height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
	Discharge IN cfs					(STANDARD PRECISION)					
11.50	1600	1610	1610	1620	1620	1630	1630	1640	1640	1650	50.0
11.60	1650*	1660	1660	1670	1670	1680	1690	1690	1700	1700	60.0
11.70	1710	1720	1720	1730	1730	1740	1750	1750	1760	1760	60.0
11.80	1770*	1780	1790	1790	1800	1810	1820	1830	1830	1840	80.0
11.90	1850	1860	1870	1870	1880	1890	1900	1910	1910	1920	80.0
12.00	1930	1940	1950	1950	1960	1970	1980	1990	1990	2000	80.0
12.10	2010*	2020	2030	2040	2050	2060	2060	2070	2080	2090	90.0
12.20	2100	2110	2120	2130	2140	2150	2150	2160	2170	2180	90.0
12.30	2190*	2200	2210	2220	2230	2240	2250	2260	2270	2280	100
12.40	2290	2300	2310	2320	2330	2340	2350	2360	2370	2380	100
12.50	2390*	2400	2410	2420	2430	2450	2460	2470	2480	2490	110
12.60	2500	2510	2520	2530	2540	2560	2570	2580	2590	2600	110
12.70	2610*	2620	2630	2650	2660	2670	2680	2690	2710	2720	120
12.80	2730	2740	2750	2770	2780	2790	2800	2810	2830	2840	120
12.90	2850	2860	2870	2890	2900	2910	2920	2930	2950	2960	120
13.00	2970*	2980	3000	3010	3020	3040	3050	3060	3070	3090	130
13.10	3100	3110	3130	3140	3150	3170	3180	3190	3200	3220	130
13.20	3230	3240	3260	3270	3280	3300	3310	3320	3330	3350	130
13.30	3360*	3370	3390	3400	3420	3430	3440	3460	3470	3490	140
13.40	3500	3510	3530	3540	3560	3570	3580	3600	3610	3630	140
13.50	3640*	3660	3670	3690	3700	3720	3740	3750	3770	3780	160
13.60	3800	3820	3830	3850	3860	3880	3900	3910	3930	3940	160
13.70	3960*	3980	4000	4020	4040	4060	4080	4100	4120	4140	200
13.80	4160	4180	4200	4220	4240	4260	4280	4300	4320	4340	200
13.90	4360	4380	4400	4420	4440	4460	4480	4500	4520	4540	200
14.00	4560	4580	4600	4620	4640	4660	4680	4700	4720	4740	200
14.10	4760	4780	4800	4820	4840	4860	4880	4900	4920	4940	200
14.20	4960	4980	5000	5020	5040	5060	5080	5100	5120	5140	200
14.30	5160	5180	5200	5220	5240	5260	5280	5300	5320	5340	200
14.40	5360*										

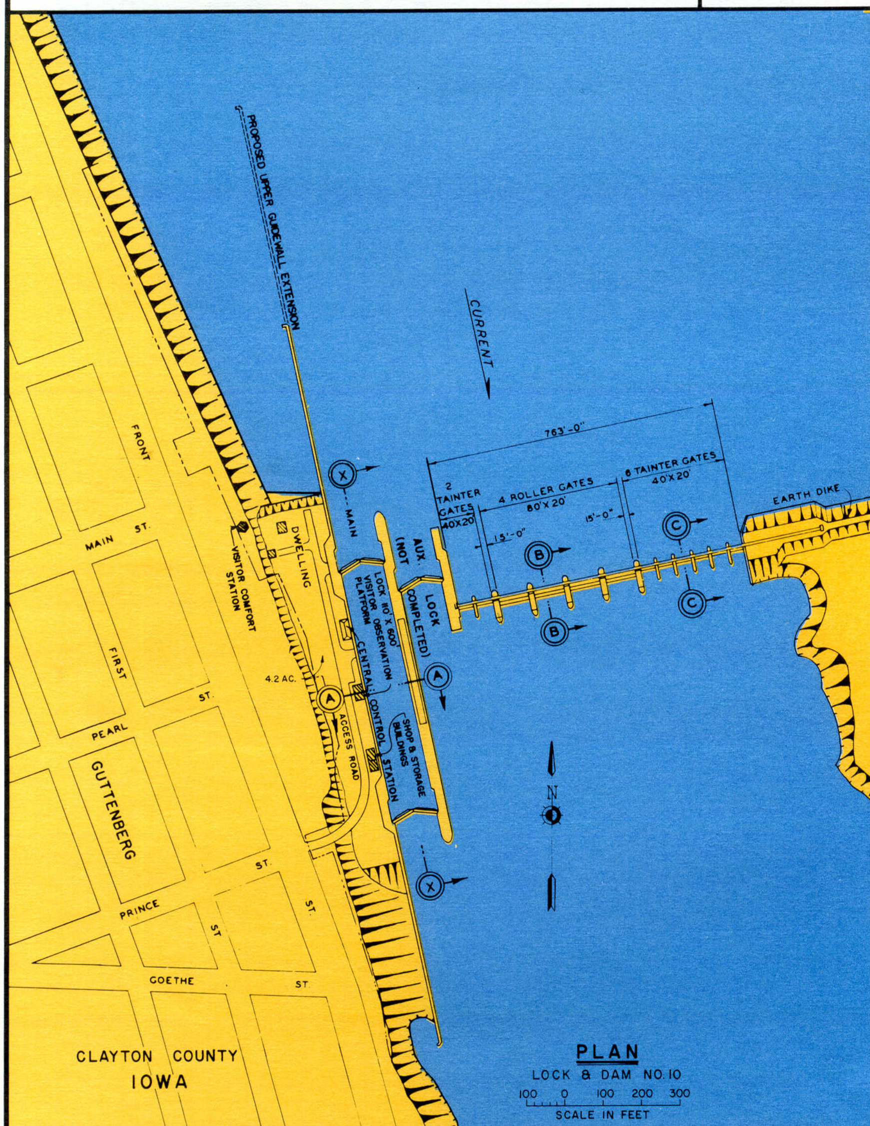
"*" indicates a rating descriptor point

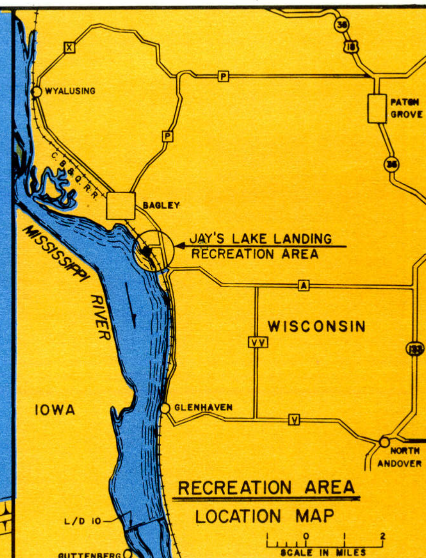
Rating Type: Rating Type: stage-discharge

ID	Starting Date	Ending Date	A	Comments
28.0	10-01-1991 @ 00:01:00 CDT	09-30-2002 @ 23:59:59 CDT	A	
28.0	10-01-2002 @ 00:00:00 CDT	-----	W	

36







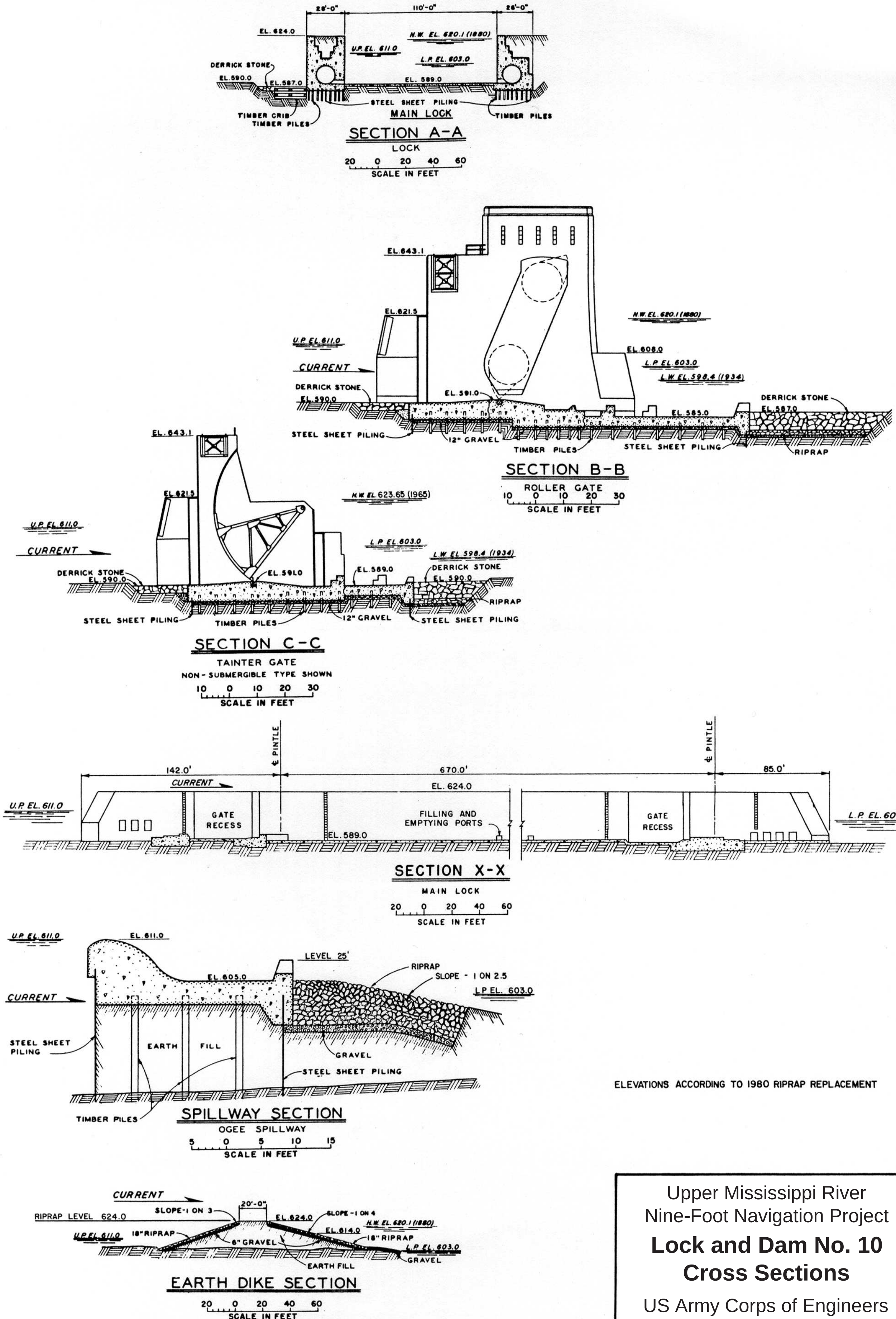
TOTAL LENGTH OF EARTH DIKE 4547.0 FT.
DEPTH ON UPPER GATE SILL - 15.0 FT. (U.P. EL. 611.0)
DEPTH ON LOWER GATE SILL - 12.0 FT. (L.P. EL. 603.0)
ELEVATION UPPER GATE SILL - 596.0
ELEVATION LOWER GATE SILL - 591.0

ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

Upper Mississippi River
Nine-Foot Navigation Project

Lock and Dam No. 10
Project Location Map

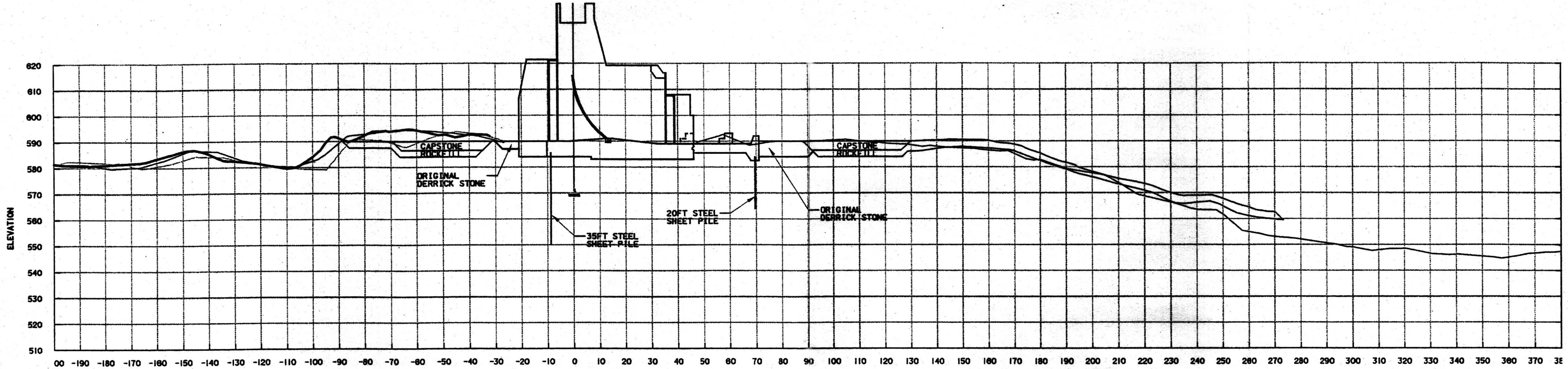
US Army Corps of Engineers
St. Paul District - 30 Sept 1977



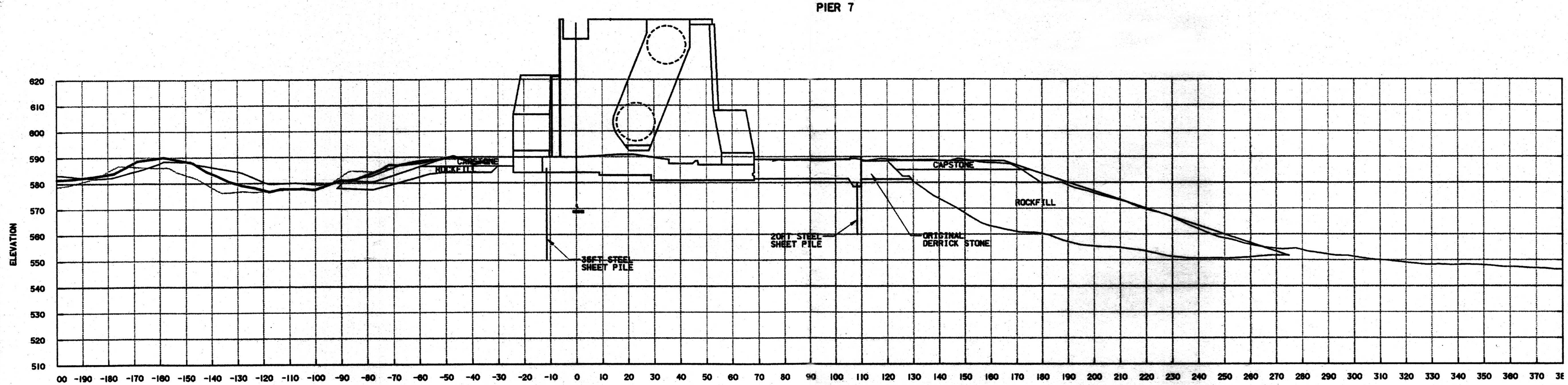
Upper Mississippi River
Nine-Foot Navigation Project

Lock and Dam No. 10
Cross Sections

US Army Corps of Engineers
St. Paul District - 30 Sept 1988



PIER 7



PIER 6

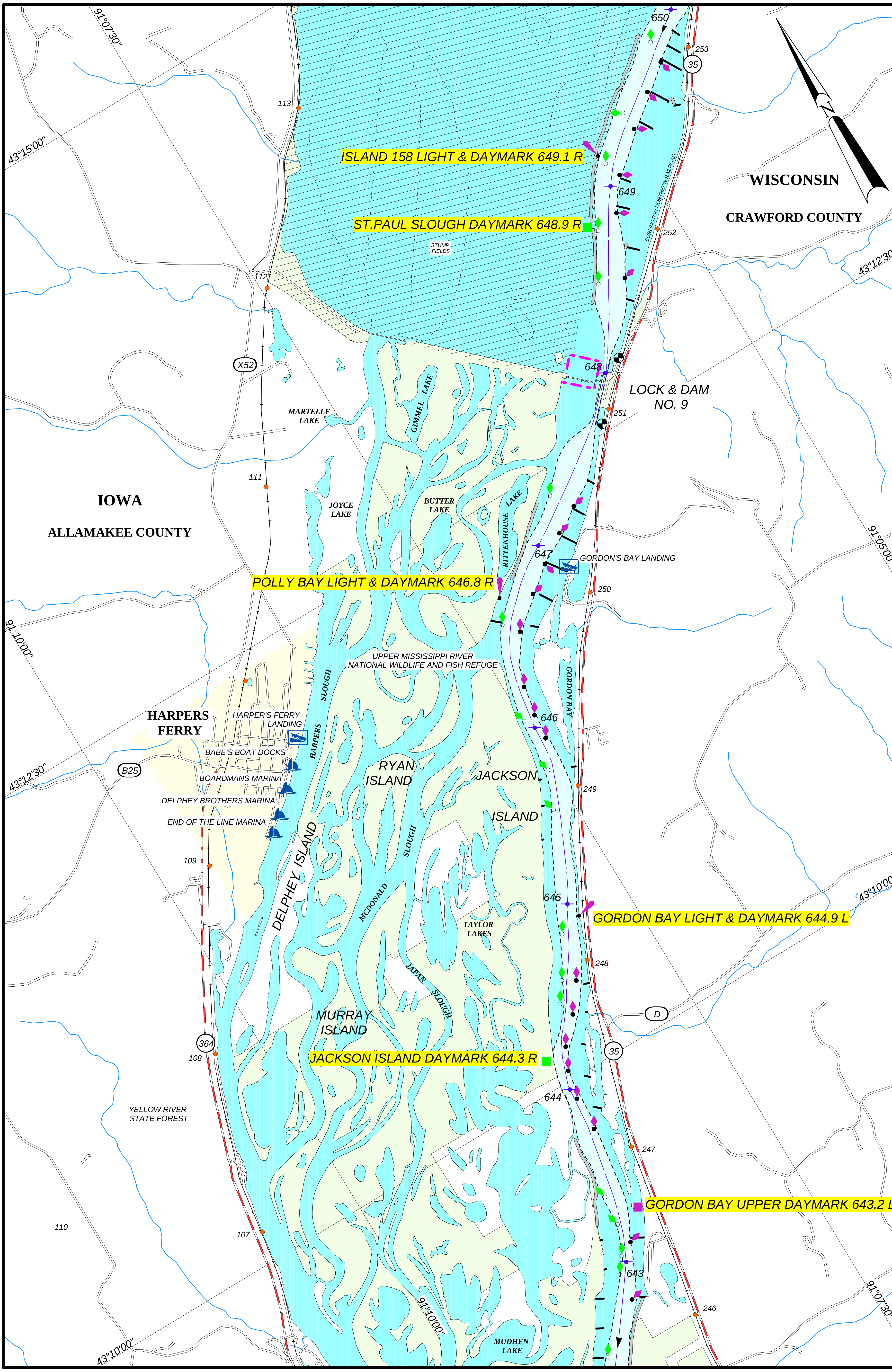
KEY

————	2001
- - - - -	2000
—-—-—	1999

Upper Mississippi River
Nine-Foot Navigation Project

Scour Protection
Upstream and Downstream of Dam
Capstone and Rockfill Placed in 1983

U.S. Army Corps of Engineers
St. Paul District – St. Paul, MN



2001

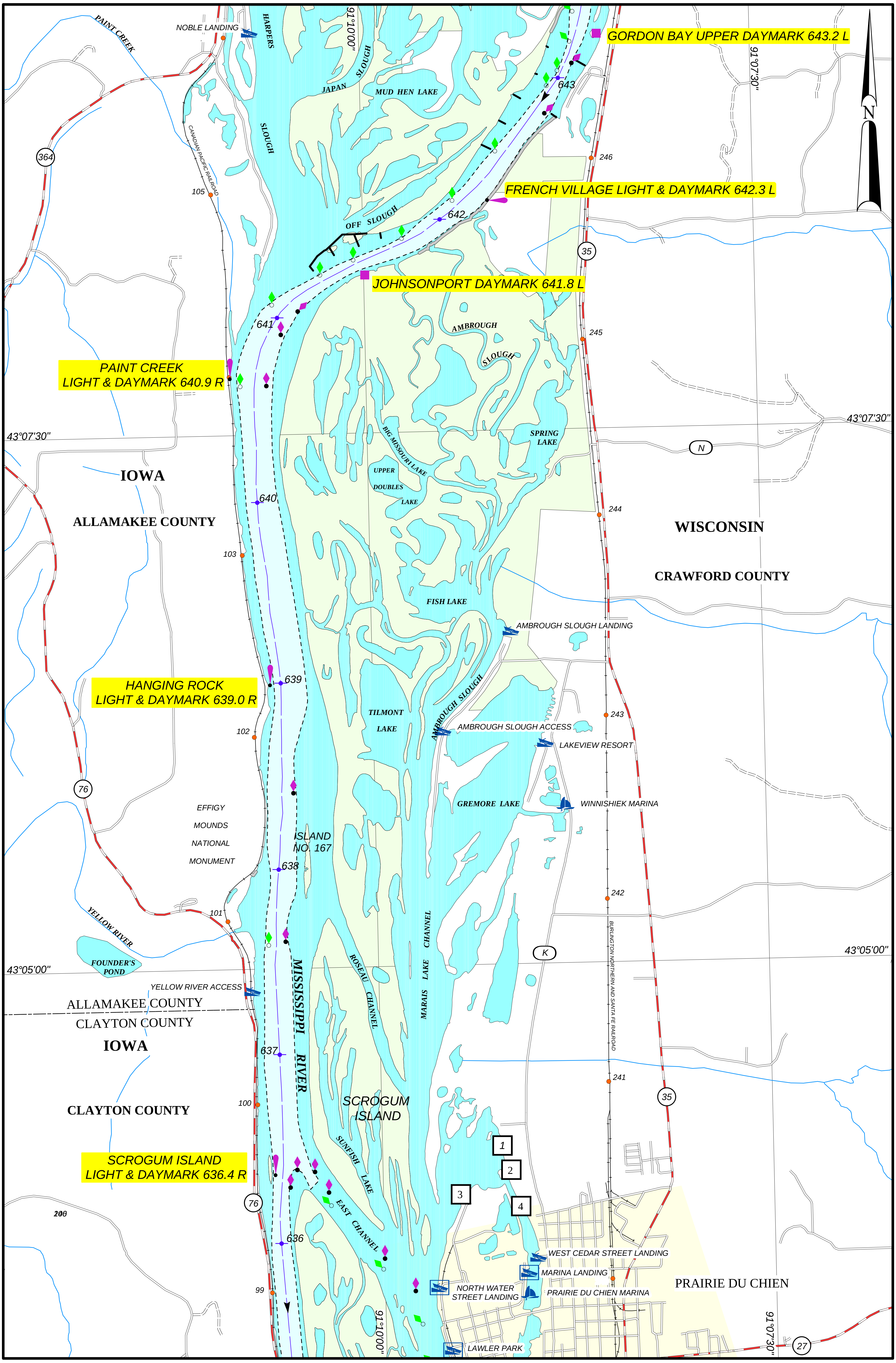
BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE

1 0.5 0 1 MILES

1 0.5 0 1 KILOMETERS

Upper Mississippi River
Nine-Foot Channel Navigation Project
Navigation Chart
River Mile 643 to 650
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN



2001

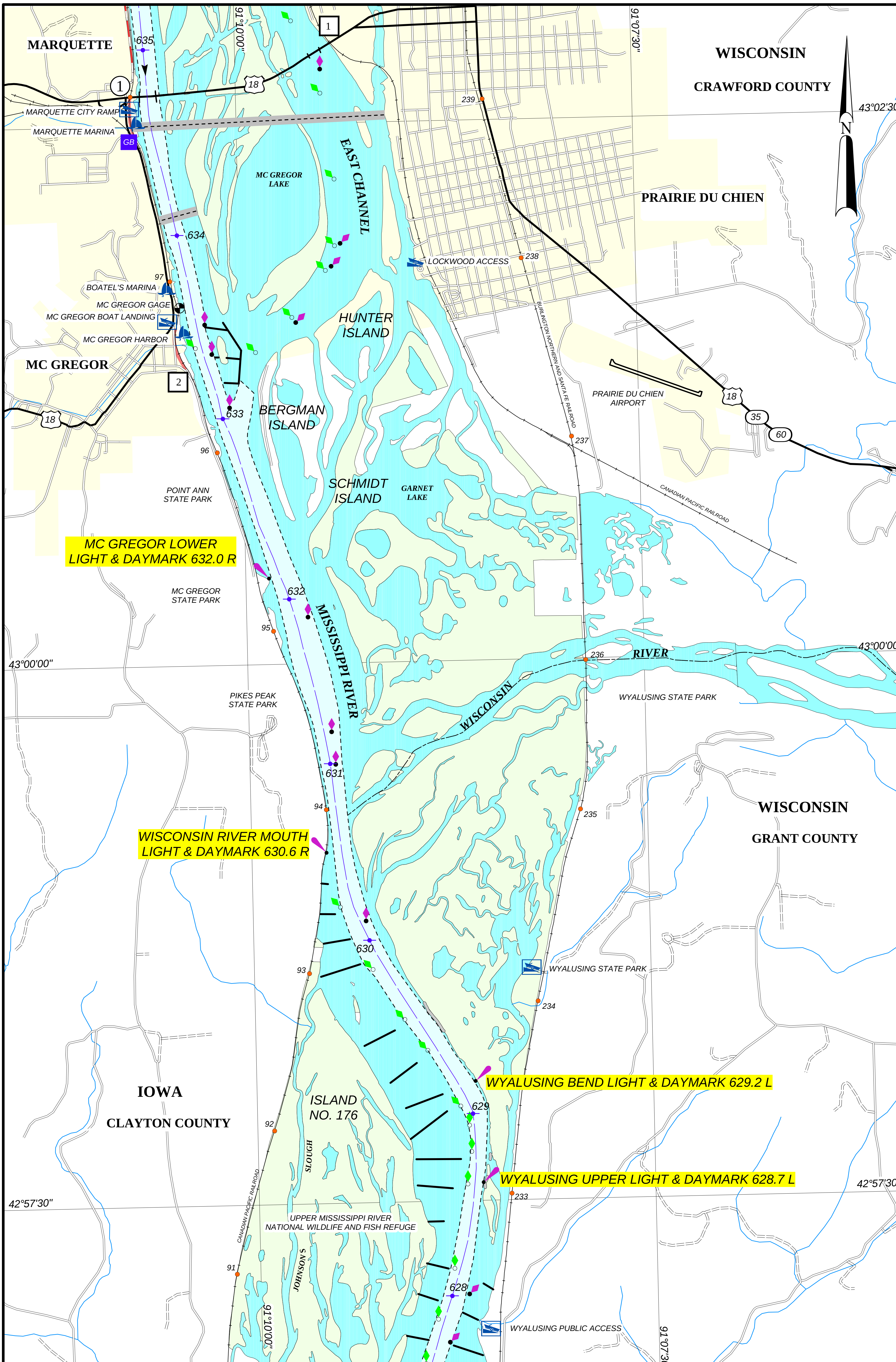
BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE

1 0.5 0 1 MILES

1 0.5 0 1 KILOMETERS

Upper Mississippi River
Nine-Foot Channel Navigation Project
Navigation Chart
River Mile 636 to 643
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN



2001

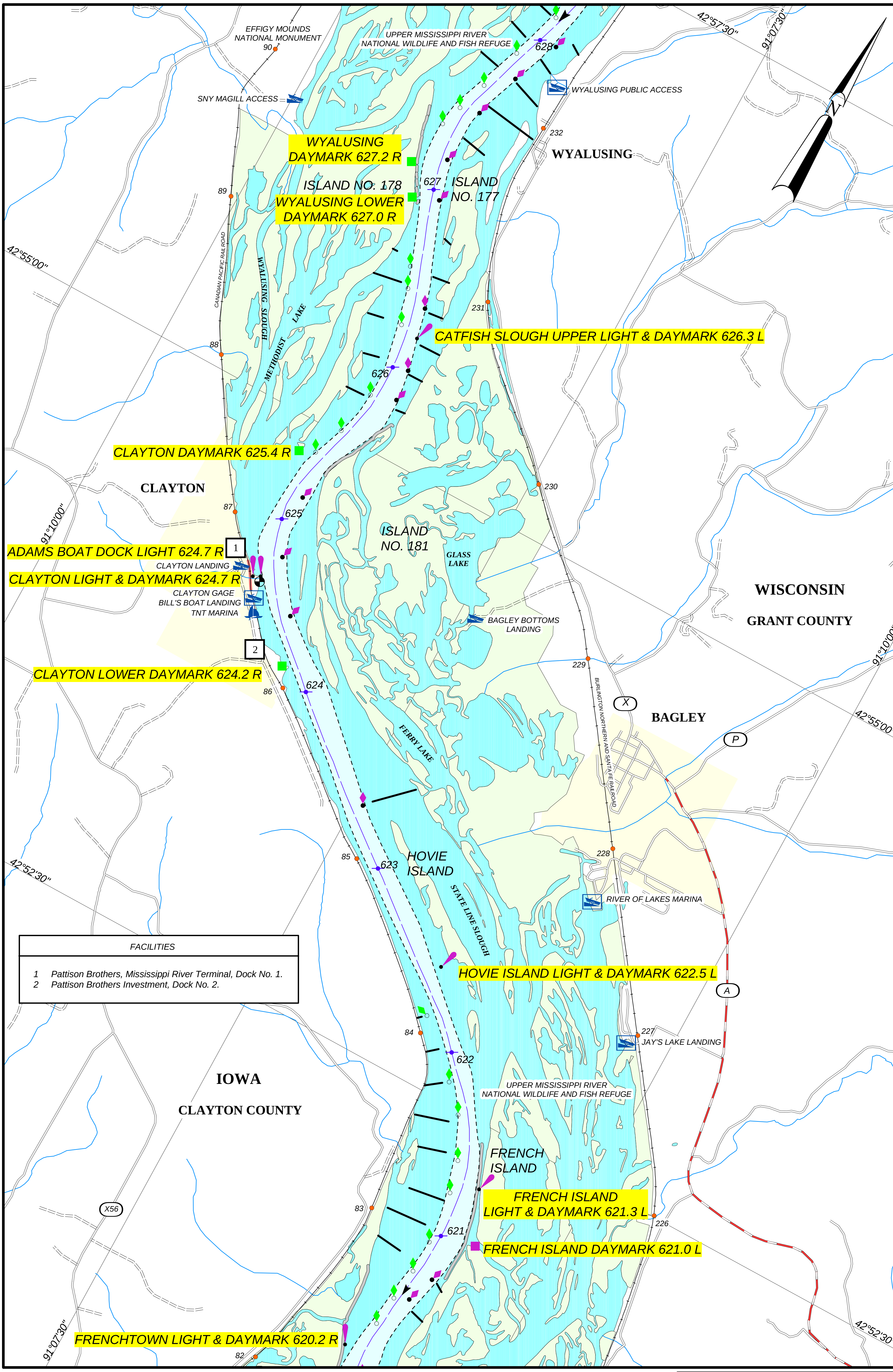
BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE

1 0.5 0 1 MILES

1 0.5 0 1 KILOMETERS

Upper Mississippi River
Nine-Foot Channel Navigation Project
Navigation Chart
River Mile 628 to 635
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN



2001

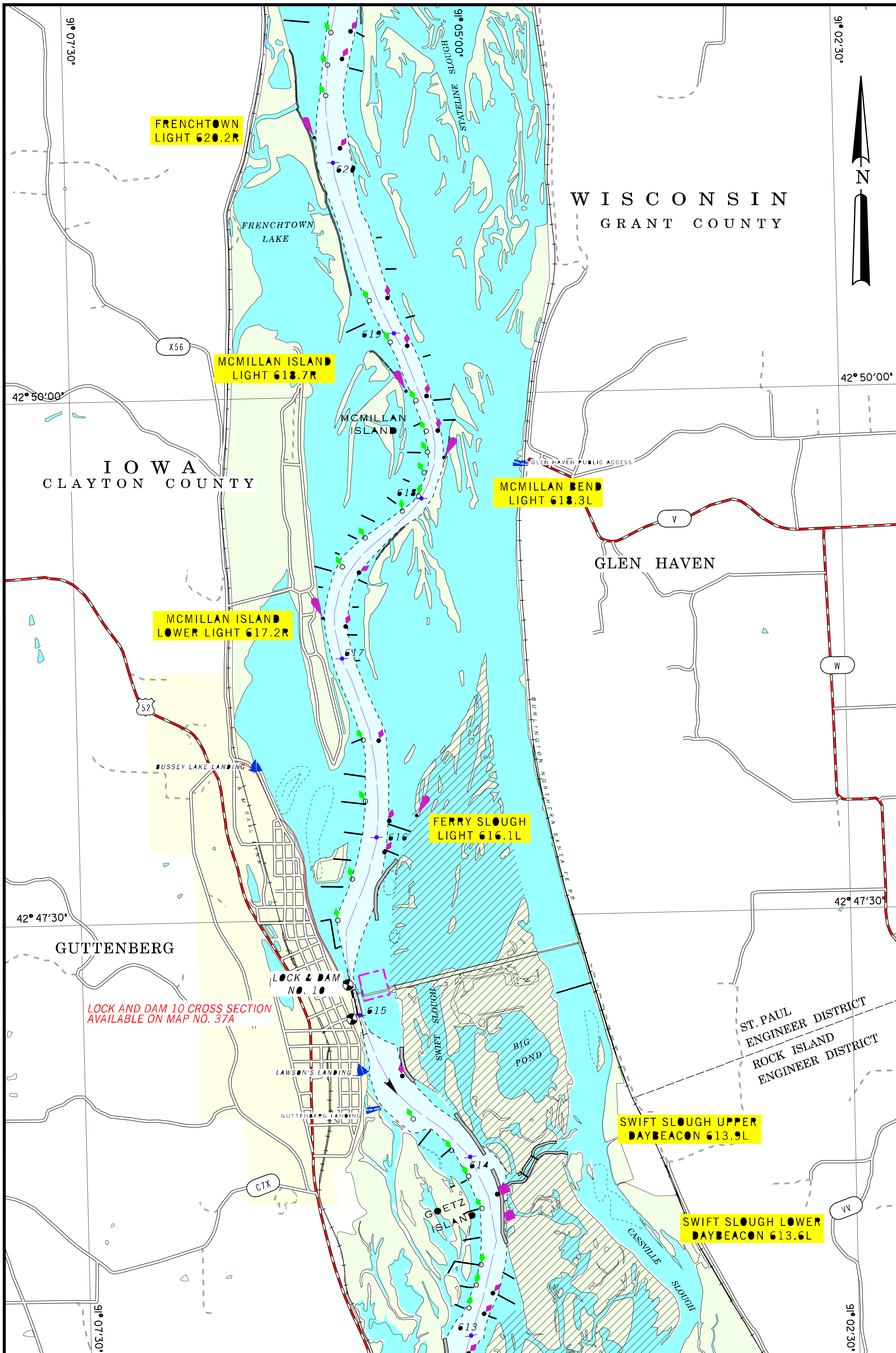
BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE

1 0.5 0 1 MILES

1 0.5 0 1 KILOMETERS

Upper Mississippi River
Nine-Foot Channel Navigation Project
Navigation Chart
River Mile 621 to 628
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN



2001

BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE

Upper Mississippi River
Nine-Foot Channel Navigation Project
Navigation Chart
River Mile 613 to 620
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN

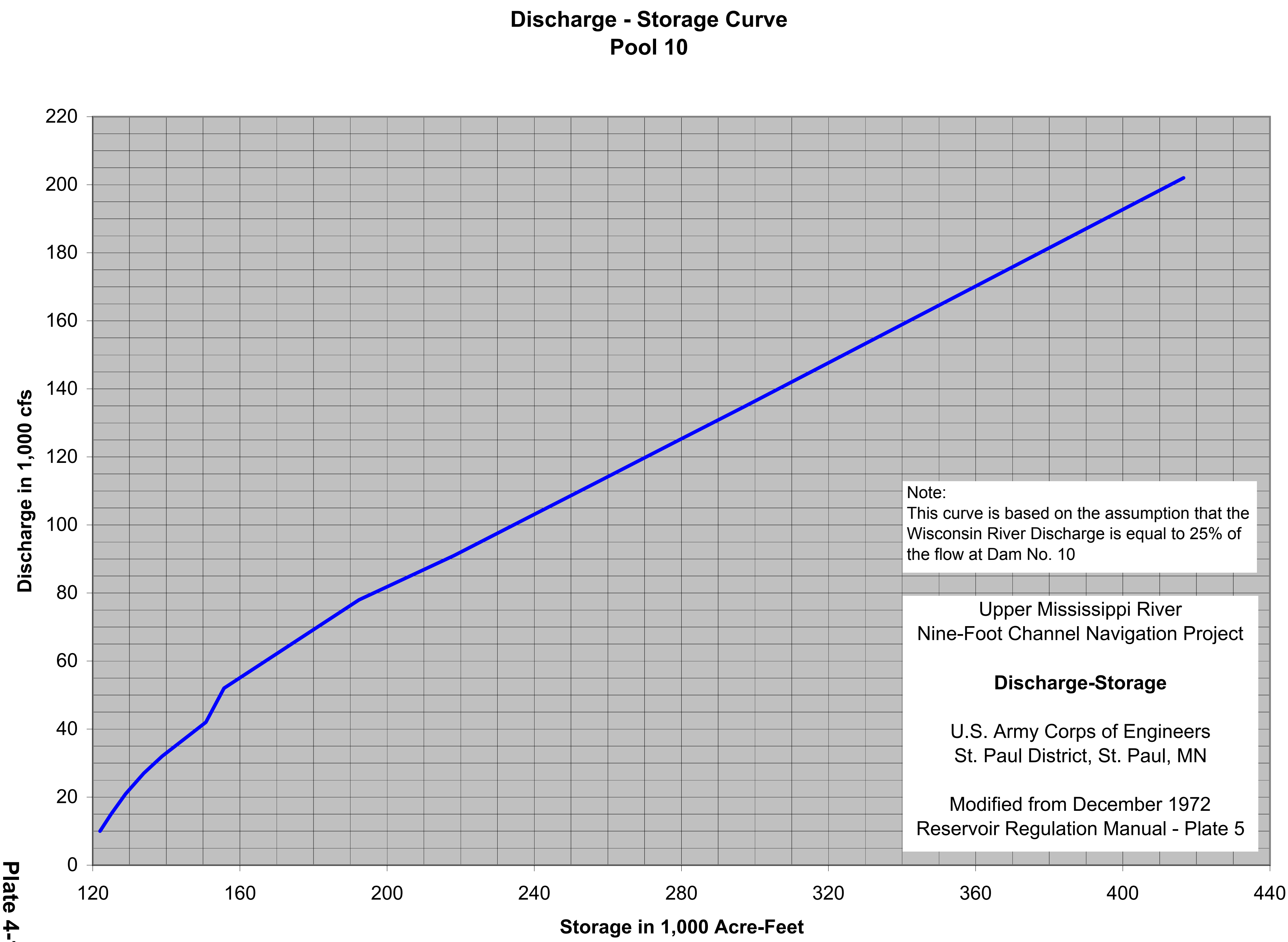
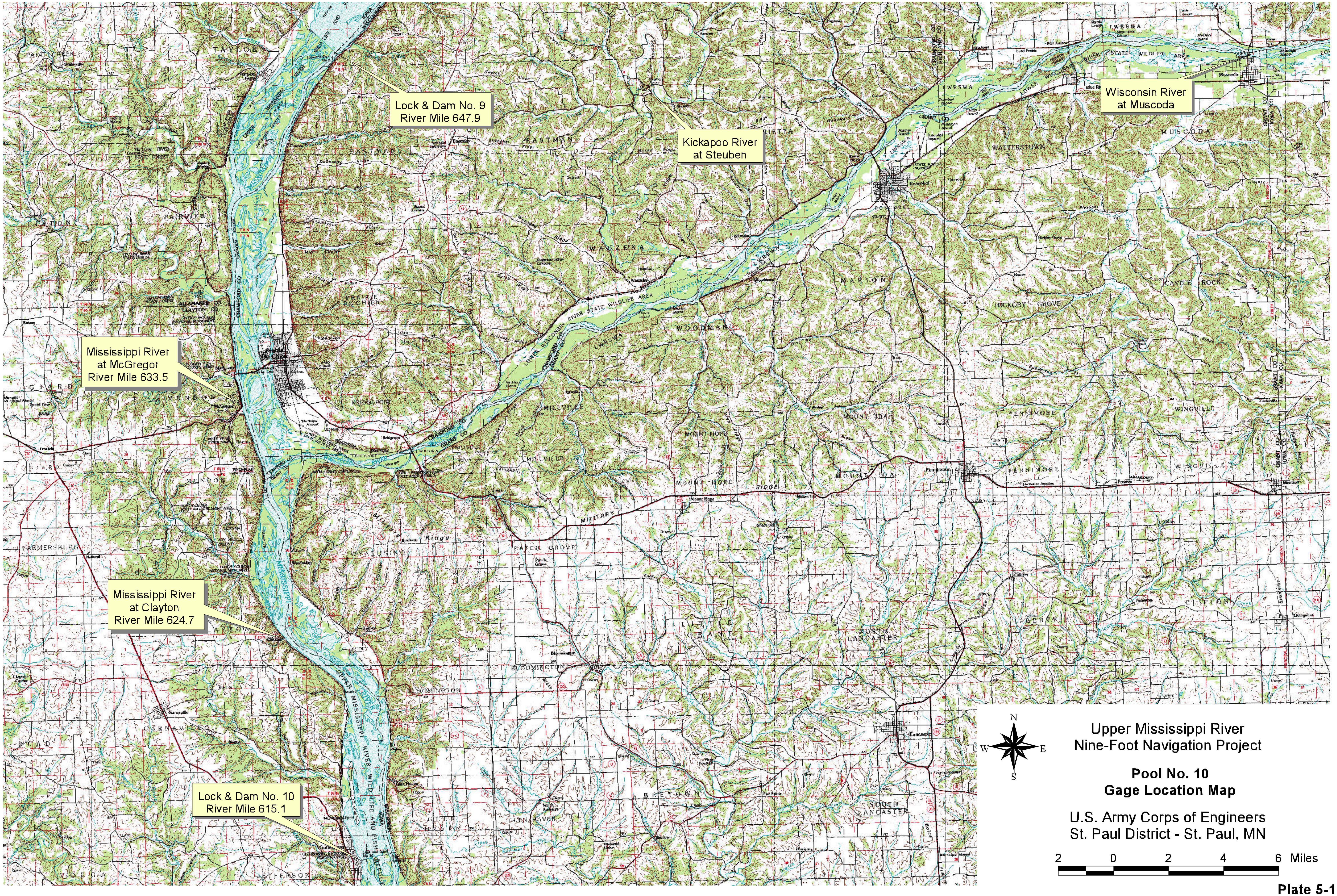

Discharge - Storage Curve
Pool 10
Discharge in 1,000 cfs
220
200
180
160
140
120
100
80
60
40
20
0
120
160
200
240
280
320
360
400
440
Storage in 1,000 Acre-Feet
Note:
This curve is based on the assumption that the Wisconsin River Discharge is equal to 25% of the flow at Dam No. 10
Upper Mississippi River
Nine-Foot Channel Navigation Project
Discharge-Storage
U.S. Army Corps of Engineers
St. Paul District, St. Paul, MN
Modified from December 1972
Reservoir Regulation Manual - Plate 5

Plate 4-1



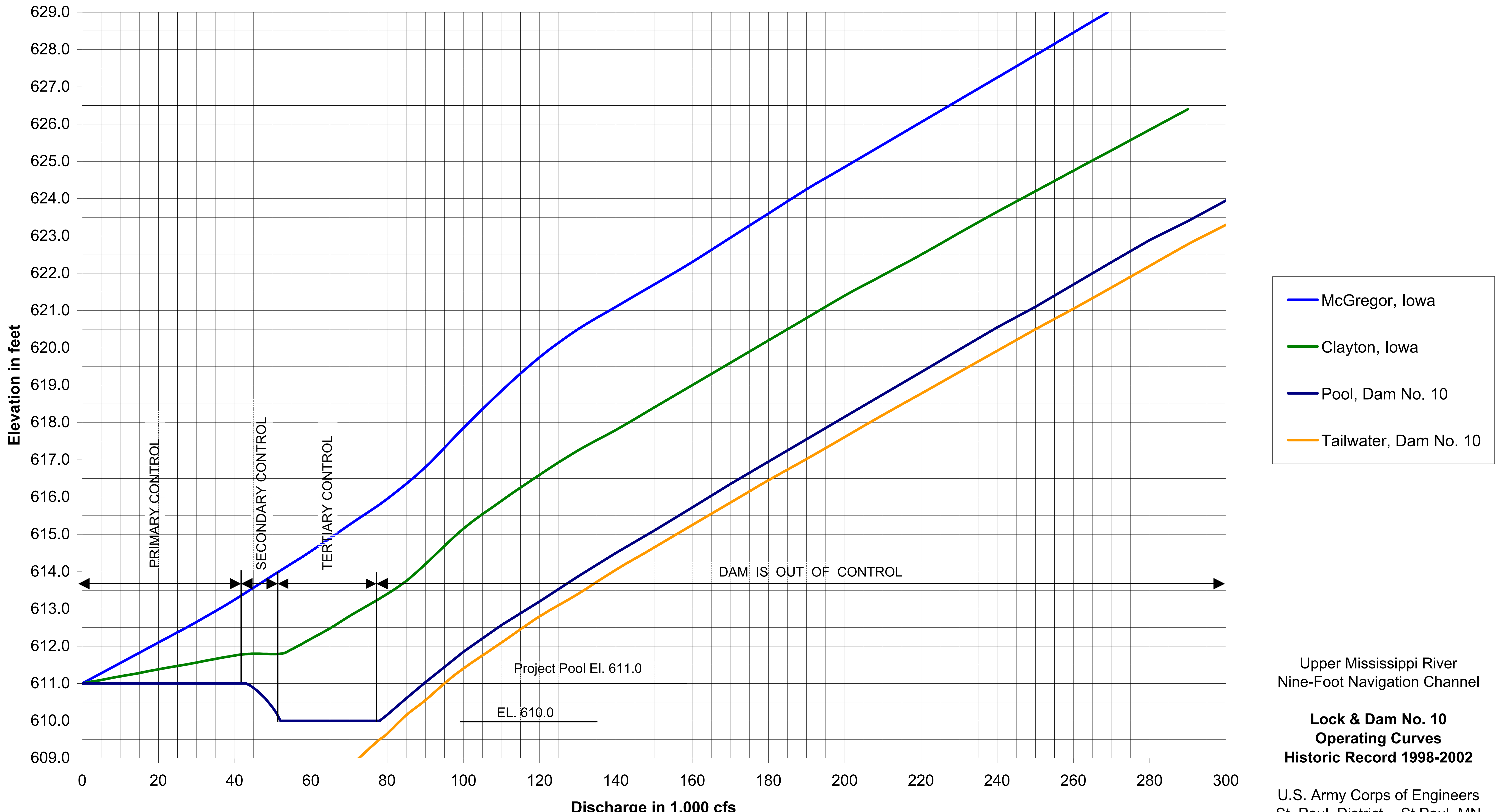
Upper Mississippi River
Nine-Foot Navigation Project

Pool No. 10
Gage Location Map

U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN

Plate 5-1

LOCK & DAM NO. 10 OPERATING CURVES

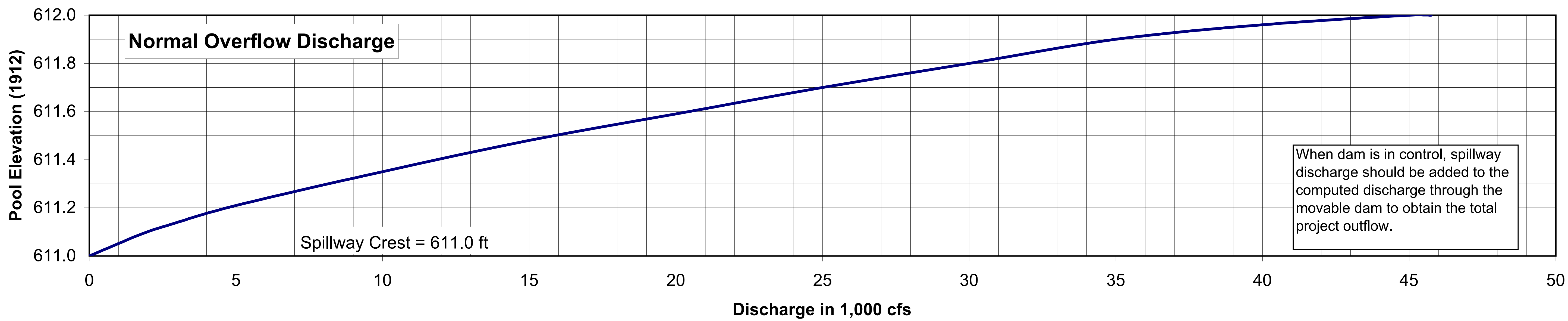


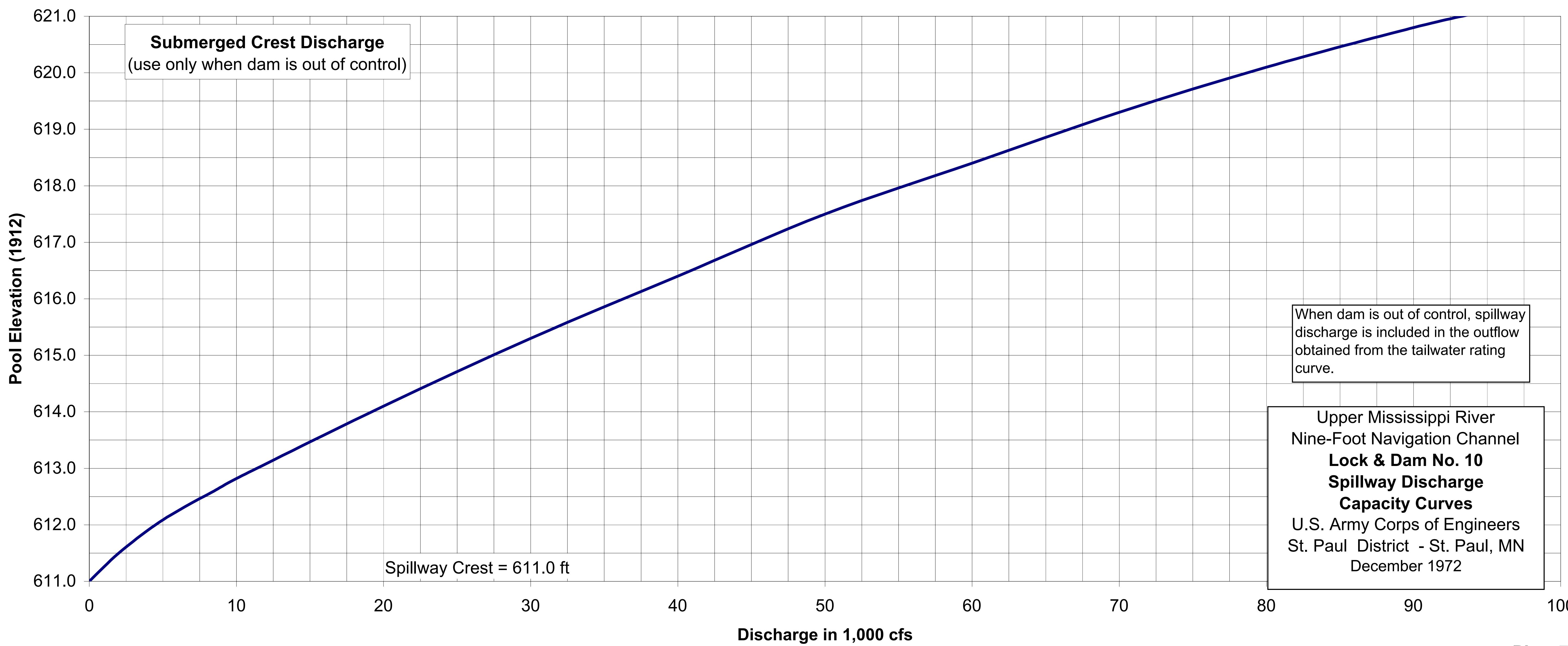
Upper Mississippi River
Nine-Foot Navigation Channel

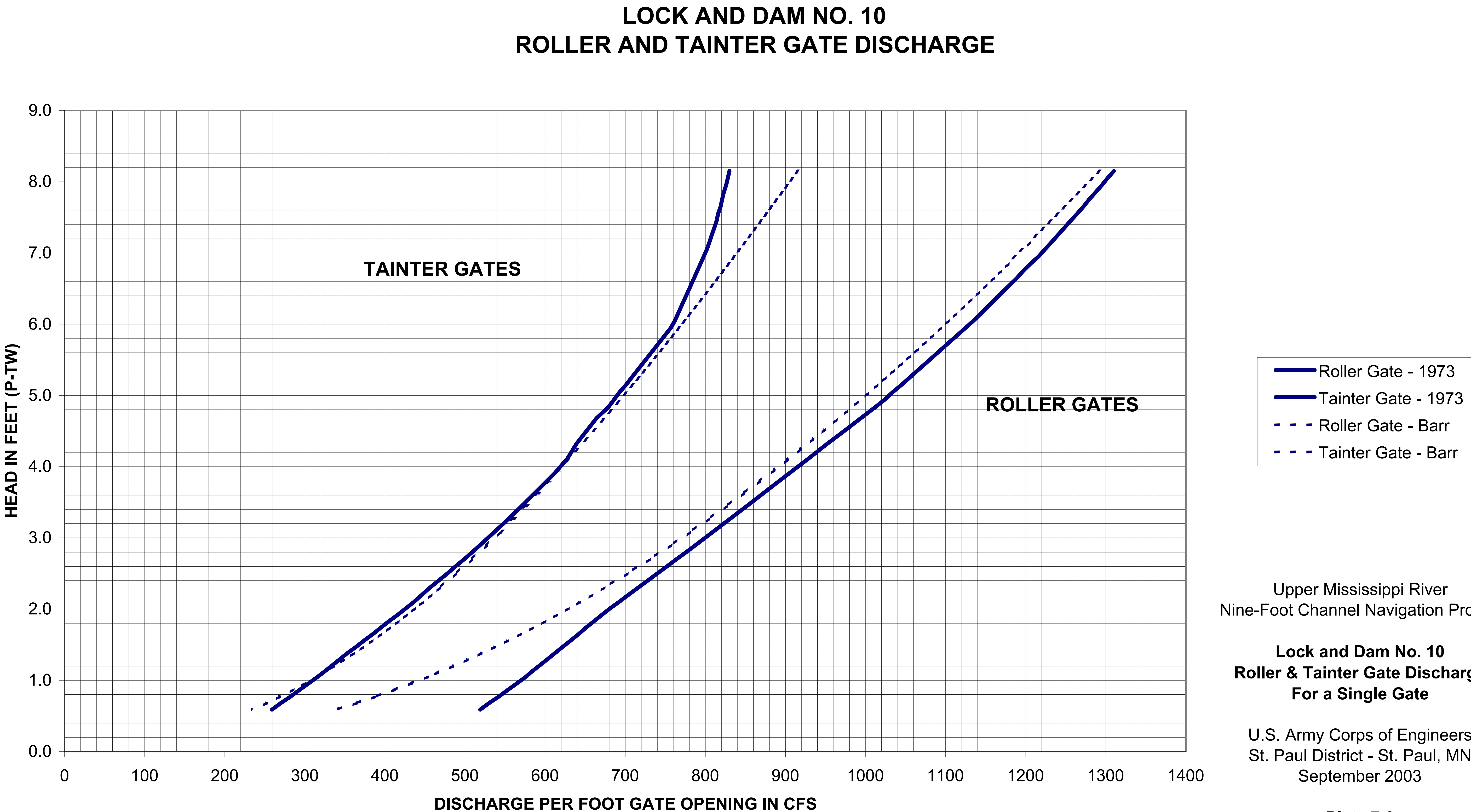
Lock & Dam No. 10
Operating Curves
Historic Record 1998-2002

U.S. Army Corps of Engineers
St. Paul District - St Paul, MN

Plate 7-1


Normal Overflow Discharge
Pool Elevation (1912)
612.0
611.8
611.6
611.4
611.2
611.0
Spillway Crest = 611.0 ft
When dam is in control, spillway discharge should be added to the computed discharge through the movable dam to obtain the total project outflow.
0
5
10
15
20
25
30
35
40
45
50
Discharge in 1,000 cfs


Submerged Crest Discharge
(use only when dam is out of control)
Pool Elevation (1912)
621.0
620.0
619.0
618.0
617.0
616.0
615.0
614.0
613.0
612.0
611.0
Spillway Crest = 611.0 ft
When dam is out of control, spillway discharge is included in the outflow obtained from the tailwater rating curve.
Upper Mississippi River
Nine-Foot Navigation Channel
Lock & Dam No. 10
Spillway Discharge
Capacity Curves
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN
December 1972
0
10
20
30
40
50
60
70
80
90
100
Discharge in 1,000 cfs



Upper Mississippi River
Nine-Foot Channel Navigation Project

Lock and Dam No. 10
Roller & Tainter Gate Discharge
For a Single Gate

U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN
September 2003

Plate 7-3

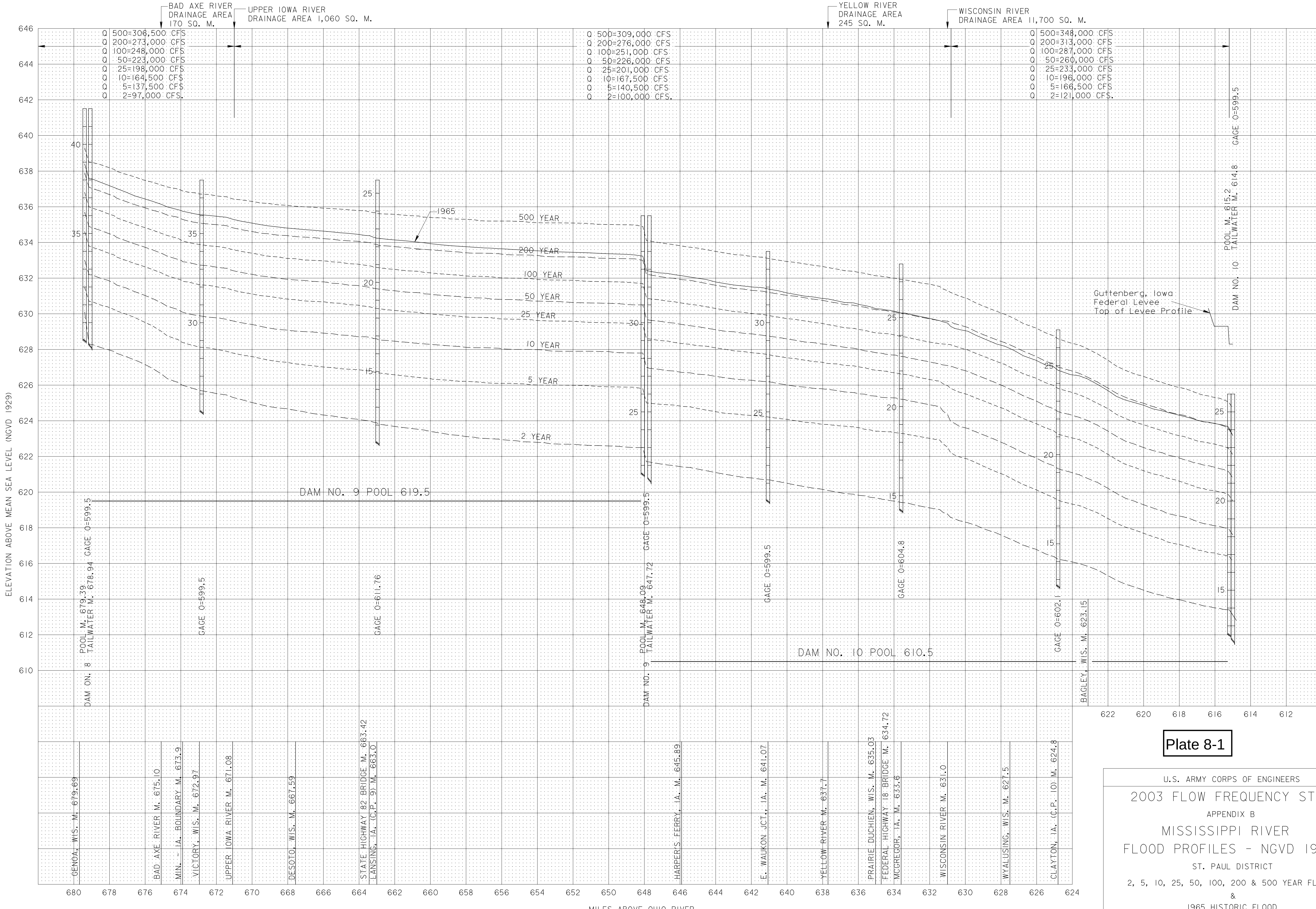


Plate 8-1

U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

MISSISSIPPI RIVER

FLOOD PROFILES - NGVD 1929

ST. PAUL DISTRICT

2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD

&

1965 HISTORIC FLOOD

RIVER MILES 615.0 TO 679.08

PLATE # 10